Appendix C – Text of Proposed Delta Plan Ecosystem Amendment

September 2021

Delta Stewardship Council

A CALIFORNIA STATE AGENCY

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Section 1 Introduction

1.1 Background

In November 2009, the California Legislature enacted Senate Bill X7 1, one of several bills passed at that time related to water supply reliability, ecosystem health, and the Sacramento–San Joaquin Delta and Suisun Marsh (Delta) (defined in Water Code [Wat. Code] section 85058). This new law took effect on February 3, 2010 and included the Sacramento–San Joaquin Delta Reform Act of 2009 (Delta Reform Act), codified in Wat. Code division 35, section 85000 et seq. The Delta Reform Act establishes the Delta Stewardship Council (Council) as an independent agency of the State of California (State) and requires the Council to develop and adopt the Delta Plan, a legally enforceable, comprehensive, long-term management plan for the Delta to achieve the coequal goals (Wat. Code sections 85001(c), 85059, and 85200(a)). As defined in Wat. Code section 85054:

> *Coequal goals means the two goals of providing a more reliable water supply for California and protecting, restoring and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource and agricultural values of the Delta as an evolving place.*

The Council adopted the Delta Plan in 2013. The Delta Reform Act requires the Council to review the Delta Plan at least once every 5 years and revise it as the Council deems appropriate (Wat. Code section 85300(c)). When the Delta Plan was adopted, the Council anticipated periodic reviews of the Delta Plan and potential need for updates in response to changing circumstances and conditions in the Delta.

The purpose of the proposed amendment to Chapter 4, *Protect Restore, and Enhance the Delta Ecosystem,* of the Delta Plan (proposed Ecosystem Amendment or Proposed Project) is to address a fundamental shift in how conservation is being planned and implemented in the Delta.

The Council, as the California Environmental Quality Act (CEQA) lead agency, has determined that an environmental impact report (EIR) is the appropriate CEQA document for the Proposed Project. Accordingly, this EIR has been prepared in compliance with CEQA (Public Resources Code [Pub. Resources Code] section 21000 et seq.) and the State CEQA Guidelines (California Code of Regulations [Cal. Code

Regs.] title 14, section 15000 et seq.). This EIR is a Program EIR (PEIR) and has been prepared pursuant to and consistent with the requirements of section 15168 of the State CEQA Guidelines. As an informational document, this Draft PEIR provides full disclosure to the public and Council regarding the potential significant environmental effects of the proposed Ecosystem Amendment, and is intended to provide sufficient information to foster informed decision-making by the Council.

This appendix to the PEIR includes the proposed Ecosystem Amendment, including the updated Chapter 4 narrative; associated regulatory and technical appendices; and updated performance measures appendix.

1.2 Organization of Appendix

The organization of this appendix is as follows:

- Section 1, this section, provides background information and on the proposed Ecosystem Amendment.
- Section 2 provides an overview of the proposed Ecosystem Amendment.

Section 2
Proposed Ecosystem Amendment

The Council is proposing to amend Chapter 4 of the Delta Plan "Protect, Restore, and Enhance the Delta" to address the shift from the Bay Delta Conservation Plan (BDCP) to EcoRestore and provide a more comprehensive approach to ecosystem protection, restoration, and enhancement in the Delta, as required to achieve the goals and strategies described in the Delta Reform Act.

The proposed Ecosystem Amendment consists of:

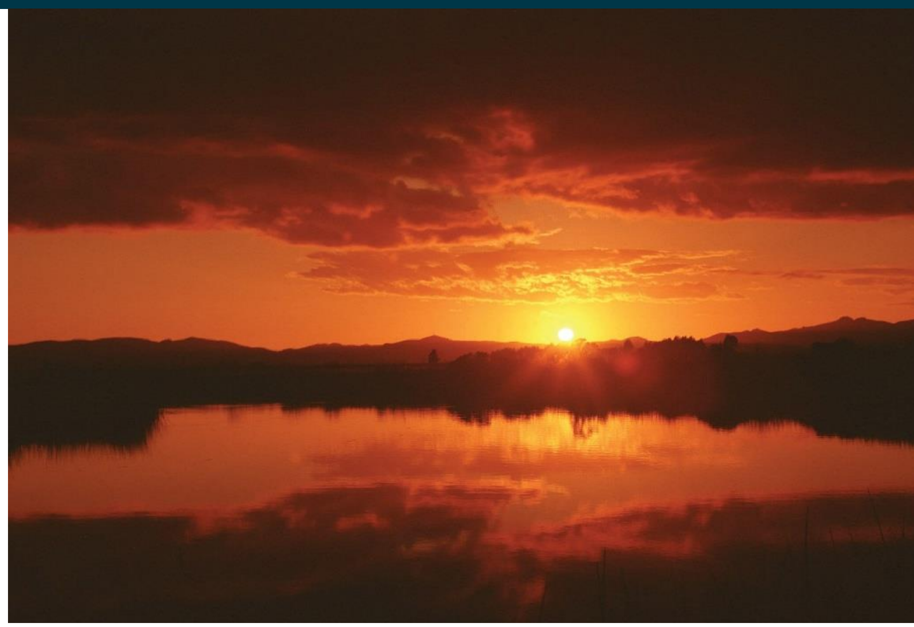
- An updated Chapter 4 narrative, including new and revised policies and recommendations, and removed recommendations (see Attachment C-1. Proposed Delta Plan Chapter 4, Protect, Restore and Enhance the Delta Ecosystem);
- Three regulatory appendices (Delta Plan Appendices 3A and 4A including new definitions; and Delta Plan Appendix 8A) (see Attachment C-2. Regulatory Appendices);
- Four technical appendices (Delta Plan Appendix Q1-Q4) (see Attachment C-3. Technical Appendices); and
- An updated appendix containing new and revised ecosystem performance measures pertinent to the coequal goal of protecting, restoring, and enhancing the Delta ecosystem, and removed performance measures (see Attachment C-4. Performance Measures).

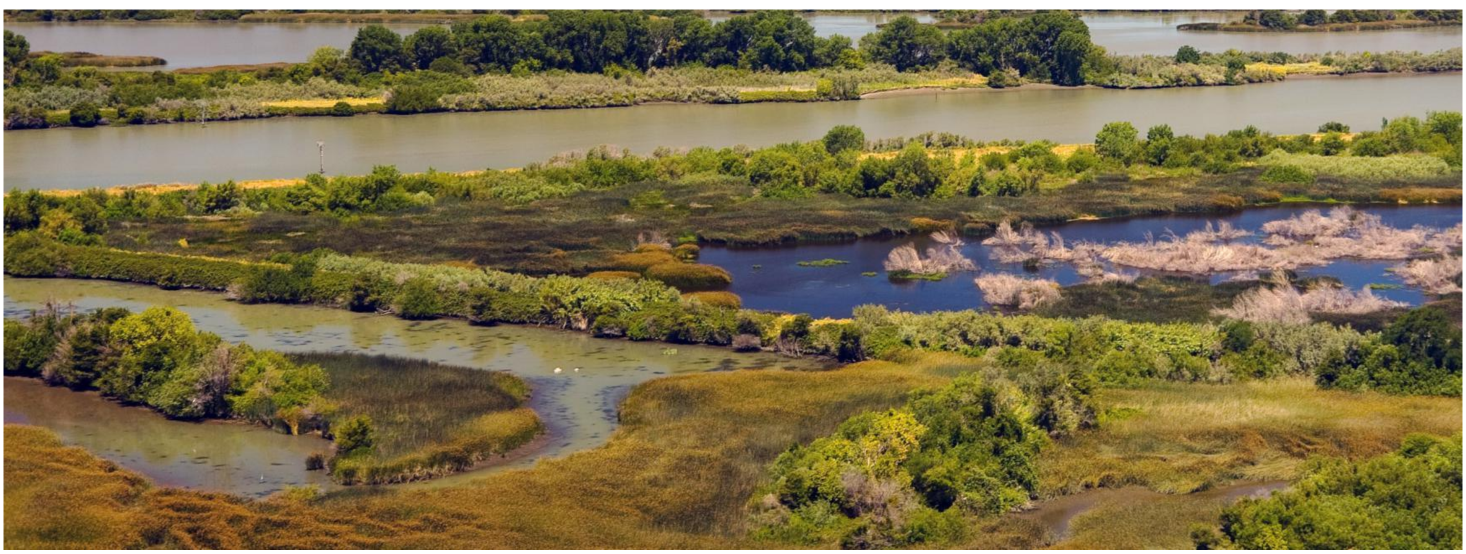
Attachment C-1
Proposed Delta Plan Chapter 4, Protect, Restore, and Enhance the Delta Ecosystem

Appendix C
Attachment C-1.1
Proposed Revised Delta Plan Chapter 4, Protect, Restore and Enhance the Delta Ecosystem

DRAFT CHAPTER 4

Protect, Restore, and Enhance the Delta Ecosystem





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About This Chapter

While significant progress has been made in implementing restoration projects since adoption of the Delta Reform Act in 2009, the Delta ecosystem continues to decline. There remains an urgent need to expand and expedite major changes to the Delta landscape, and to align state and federal priorities to hasten the creation of new opportunities to protect, restore, and enhance the Delta ecosystem. Additional research and scientific information will be needed to guide management decisions as climate change accelerates and as new opportunities for restoration arise within the Delta and its watershed.

This chapter presents **five core strategies** to achieve the coequal goal of protecting, restoring, and enhancing the Delta ecosystem, as set forth in the Delta Reform Act:

1. Create more natural, functional flows
2. Restore ecosystem function
3. Protect land for restoration and safeguard against land loss
4. Protect native species and reduce the impact of nonnative invasive species
5. Improve institutional coordination to support implementation of ecosystem protection, restoration, and enhancement

These core strategies form the basis for the six policies and fifteen recommendations pertinent to the coequal goal of protecting, restoring, and enhancing the Delta ecosystem, which are found at the end of this chapter.

Relevant Legislation

The coequal goals for the Delta (California Water Code section 85054) are relevant to ecosystem restoration:

> *"Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.*

Eight objectives in California Water Code section 85020 are inherent in the coequal goals, and three are relevant to this chapter (Section 85020(a), (c), and (e)):

> *85020 The policy of the State of California is to achieve the following objectives that the Legislature declares are inherent in the coequal goals for management of the Delta:*
>
> > *(a) Manage the Delta's water and environmental resources and the water resources of the state over the long term.*
> >
> > *(c) Restore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem.*
> >
> > *(e) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

The coequal goals and inherent objectives seek broad protection of the Delta. Achieving these broad goals and objectives requires implementation of specific strategies. California Water Code sections 85022 and 85302 provide direction on the implementation of specific measures to promote the coequal goals and inherent objectives related to the Delta ecosystem restoration. Those relevant to this chapter are:

85022(d) The fundamental goals for managing land use in the Delta are to do all of the following:

> *(1) Protect, maintain, enhance, and, where feasible, restore the overall quality of the Delta environmental and its natural and artificial resources.*
>
> *(2) Ensure the utilization and conservation of Delta resources, taking into account the social and economic needs of the people of the state.*
>
> *(5) Develop new or improved aquatic and terrestrial habitat and protect existing habitats to advance the goal of restoring and enhancing the Delta ecosystem.*
>
> *(6) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

85302(a) The implementation of the Delta Plan shall further the restoration of the Delta ecosystem and a reliable water supply.

85302(b) The geographic scope of the ecosystem restoration projects and programs identified in the Delta Plan shall be the Delta, except that the Delta Plan may include recommended ecosystem projects outside the Delta that will contribute to achievement of the coequal goals.

85302(c) The Delta Plan shall include measures that promote all of the following characteristics of a healthy Delta ecosystem:

> *(1) Viable populations of native resident and migratory species.*
>
> *(2) Functional corridors for migratory species.*
>
> *(3) Diverse and biologically appropriate habitats and ecosystem processes.*
>
> *(4) Reduced threats and stresses on the Delta ecosystem.*

> *(5) Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations.*

85302(d) The Delta Plan shall include measures to promote a more reliable water supply that address… the following:

> *(1) Meeting the needs for reasonable and beneficial uses of water.*

> *(3) Improving water quality to protect human health and the environment.*

85302(e) The following subgoals and strategies for restoring a healthy ecosystem shall be included in the Delta Plan:

> *(1) Restore large areas of interconnected habitats within the Delta and its watershed by 2100.*

> *(2) Establish migratory corridors for fish, birds, and other animals along selected Delta river channels.*

> *(3) Promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm from invasive species.*

> *(4) Restore Delta flows and channels to support a healthy estuary and other ecosystems.*

> *(5) Improve water quality to meet drinking water, agriculture, and ecosystem long-term goals.*

> *(6) Restore habitat necessary to avoid a net loss of migratory bird habitat and, where feasible, increase migratory bird habitat to promote viable populations of migratory birds.*

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CHAPTER 4

Protect, Restore, and Enhance the Delta Ecosystem

The Delta Stewardship Council (Council) works to achieve the goal of protecting, restoring, and enhancing the Delta ecosystem (California Water Code section 85054). Inherent in that goal is the objective to “restore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem” (California Water Code section 85020[c]). This chapter presents core strategies, policies, and recommendations for protecting, restoring, and enhancing the Delta ecosystem, based on current scientific understanding of opportunities and constraints, to achieve that coequal goal, and to benefit both the Delta ecosystem and native resident and migratory species (see highlighted section on the next page, “What Does It Mean to Achieve the Goal of Protecting, Restoring, and Enhancing the Delta Ecosystem?”). Success will require continued collaboration among local, state, and federal agencies, and strong partnerships with nongovernmental organizations and the private sector.

The Delta: A Unique Ecological Resource

The Delta and Suisun Marsh (together, “the Delta” [23 CCR 5001(k)]) are part of the largest estuary on the west coast of the Americas. The Delta’s system of channels, bays, and sloughs connects the upper watersheds of the Sacramento Valley, the foothills of the Sierra Nevada Mountains, and the great Central Valley to Suisun Marsh, the San Francisco Bay, and marine environments of the Pacific Ocean. Suisun Marsh is one of the largest contiguous estuarine wetlands in North America; an important nursery for fish; a wintering and nesting area for waterfowl and waterbirds; and an essential habitat for plants, fish, and wildlife, including several scarce and sensitive species.

The ecosystems supported by the Delta and its watersheds are an integral component of the California Floristic Province, one of 25 biodiversity hotspots of global importance for conservation of species (Myers et al. 2000, Healey et al. 2016, Appendix Q4). Because it is located at the confluence of California’s two largest rivers, the Delta serves as a key migration corridor for many fish and wildlife species. All Central Valley anadromous fish species migrate through the Delta, as adult fish return to their home rivers and streams to spawn, and juveniles migrate out to the ocean.

The Delta also serves as important juvenile fish rearing habitat. For example, juvenile Chinook salmon and steelhead depend on the Delta as transient rearing habitat while they migrate to the ocean. Juvenile anadromous fish can remain in the Delta for several months, feeding in wetlands, tidal flats, and sloughs. Other fish species, including the native delta smelt, longfin smelt, and Sacramento splittail, are year-long estuary residents. Suisun Marsh harbors a greater percentage of native fish than the remainder of the Delta, in part because its brackish water limits nonnative species. Additionally, the marsh has many diverse tidal sloughs that provide food and refuge (Moyle et al. 2010).

The Delta also serves as a critical link between Sacramento Valley and San Joaquin Valley terrestrial wildlife populations. The Delta and its watershed provide a unique habitat resource for more than 200 species of marine and freshwater fish, as well as millions of migratory waterfowl and other migratory and resident birds (Council 2018a, Appendix Q4). Delta waterways help support California’s $1.5 billion commercial and recreational fishing industries (TNC 2017). Maintaining the Delta ecosystem is critical for supporting the 80 percent of commercial fishery species that migrate through or live in the Delta (Water Education Foundation 2019).

WHAT DOES IT MEAN TO ACHIEVE THE COEQUAL GOAL OF PROTECTING, RESTORING, AND ENHANCING THE DELTA ECOSYSTEM?

Achieving the coequal goal of ecosystem protection, restoration, and enhancement means successfully establishing a resilient, functioning estuary and surrounding terrestrial landscape capable of supporting viable populations of native, resident and migratory species with diverse and biologically appropriate habitats, functional corridors, and ecosystem processes (23 California Code of Regulations (CCR) section 5001[h][2]).

As defined in the Delta Plan, the term *restoration* means:

> *"the application of ecological principles to restore a degraded or fragmented ecosystem and return it to a condition in which its biological and structural components achieve a close approximation of its natural potential, taking into consideration the physical changes that have occurred in the past and the future impact of climate change and sea level rise" (California Water Code section 85066, see also 23 CCR section 5001[bb]).*

Restoration actions may include restoring interconnected habitats within the Delta and its watershed, restoring more natural Delta flows, or improving ecosystem water quality (23 CCR section 5001[bb]). This, in turn, can contribute to species recovery.

Protection means "*preventing harm to the ecosystem, which could include preventing the conversion of existing habitat, the degradation of water quality, irretrievable conversion of lands suitable for restoration, or the spread of invasive nonnative species*" (23 CCR section 5001[z]).

Enhancement means "*improving existing desirable habitat and natural processes*" (23 CCR section 5001[o]). For example, enhancement includes flooding the Yolo Bypass more often to support native species or to expand or better connect existing habitat areas. Enhancement also includes many fish and wildlife management practices, such as managing wetlands for waterfowl production or shorebird habitat, installing fish screens to reduce entrainment of fish at water diversions, or removing barriers that block migration of fish to upstream spawning habitats (23 CCR section 5001[o]).

The Delta's Historical Ecology

The pre-1849 Delta and Central Valley supported extensive wetland, riparian, and grassland ecosystems which provided habitat for more than 750 species of plants, fish, and other wildlife (Healey et al. 2008, Healey et al. 2016). These ecosystems produced significant organic carbon through a process known as primary production, providing energy to support the estuary food web (The Bay Institute 1998). The dynamic nature of salinity within the Delta supported a resident fish community which included both brackish-water and freshwater species (The Bay Institute 1998).

Through the early 1800s, rivers traversed approximately 400,000 acres of tidal wetlands and other aquatic habitats in the Delta, connecting with several hundred thousand acres of nontidal wetlands and riparian forest (see Figure 4-1). Delta river and tidal channel flows varied by season and year to year, sometimes pouring from the Sierra in great floods whose fresh waters overflowed wetlands and floodplains, and at other times declining as droughts shriveled rivers and brackish tidewaters pushed inland. The Delta's historical landscape also varied from north to south. In the north Delta, flood basins occurred where the Sacramento River intertwined with tidal channels. A vast area of freshwater wetlands dominated by tules transitioned into tidal wetlands. Shallow perennial ponds and lakes, broad riparian forests along natural levees, and seasonal wetlands at the upland edge were also common. The central Delta was characterized by large, tidal islands that flooded during spring tides, or more frequently, were intersected by networks of branching tidal channels. Low channel banks were covered by the willows, grasses, sedges, and shrubs that also grew in island interiors. The south Delta contained a complex network of channels formed predominantly by riverine processes. The floodplain was comprised of emergent wetlands, perennial and seasonal ponds, willow thickets, and seasonal wetlands. Driftwood and other woody debris, from riparian forests along the rivers, filled some channels. Suisun Marsh was a brackish marsh characterized by variability in hydrodynamics, salinity, and wind patterns, creating a diverse mosaic of tidal marsh, islands, and mudflats; shallow ponds, pannes, and vernal pools; and upland transition zones (Manfree 2014).

Historical records describe a rich and complex Delta with habitats supporting diverse and abundant native plants and animals (Grossinger et al. 2010, Whipple et al. 2010, Whipple et al. 2012). Some fish, including delta smelt, schooled in the open waters of bays and channels in the western Delta, and moved east when brackish water intruded from San Francisco Bay. Other resident wildlife and plants also prospered: native birds such as rails in tidal and tule marshes; giant garter snakes in freshwater wetlands and ponds; and riparian brush rabbits and riparian woodrats in willow thickets and riparian forests. Each fall, salmon and steelhead, drawn by the swelling Sacramento and San Joaquin Rivers, migrated inland from the ocean and navigated upstream to spawning areas in tributaries. As river flows receded, their offspring, emerging from the tributaries' spawning gravel, would return downstream and shelter in driftwood-lined eddies or undercut riverbanks, feeding in Delta sloughs, wetlands, and floodplains before returning to the sea. Waterfowl, cranes, and shorebirds migrated through the Delta along a north-south route stretching from the Arctic to Mexico or beyond. Songbirds followed a similar path through connected riparian woodlands from the Sacramento Valley through the Delta to the San Joaquin Valley.

Indigenous peoples have lived in the Delta for thousands of years, and they made use of many Delta plant, animal, and mineral resources (Helzer 2015). Research over the past several decades has revealed extensive indigenous knowledge of the use of burning to manage the Delta landscape. Indigenous peoples used burning to maintain grassland cover and forage for animals, to improve seed and acorn access, to aid in hunting small game, to control chaparral distribution, and to reduce pathogens and parasites such as ticks (Keeley 2002, Anderson 2005). Indigenous peoples also tended certain plant species, particularly those used for basketry material such as sedge, willow, dogwood, and redbud, through regular pruning and rhizome harvesting and through regular overturning of the soil as part of tuber harvesting (Anderson 2005, Zedler and Stevens 2018). Milkweed and hemp, which were tended to and supplied food for pollinators, are now largely absent. Fish habitat was likely enhanced by indigenous management of riparian areas (Zedler and Stevens 2018). Tribal modification and tending of the Delta was likely extensive and profound; ethnographies suggest that there were at least 20 native villages spread throughout the Delta at key locations (Schenck 1926, Levy 1978).

Indigenous cultures place great value on managing plants and wildlife for maintaining a broad diversity of species and environments within the natural landscape. Many species play important roles in traditional stories, the understanding of place, and the practical use in everyday life (Hankins 2018). These roles contribute to these resources being important aspects of tribal cultures. Resources of particular cultural importance for indigenous peoples who lived within the estuary for millennia include important food staples such as fish (e.g., Chinook salmon); certain herbs, roots, and berries used for medicine; and plants which provided fiber for personal use or trade (e.g., tules used to construct shelters, and “white root” sedges and willows used for basket-weaving) (Zedler and Stevens 2018). Indigenous Californians might have harvested over 500 species of plants alone for various uses (Zedler and Stevens 2018).

Euro-American settlement of the Delta had a devastating effect on the area’s tribes, and led to the 1833 epidemic, which, according to some estimates, may have resulted in the death of 75 percent of the region’s indigenous peoples (Cook 1955, Castillo 1978). This loss, as well as displacement and removal from traditional lands, effectively ended wide-scale indigenous landscape management in the Delta and Suisun Marsh by the mid-nineteenth century. Indigenous peoples continue to maintain strong relationships with Delta lands, waters, and organisms (Hankins 2018).

EXAMPLES OF HISTORICAL DELTA ECOSYSTEMS

While the Delta will never be restored to historical conditions, a few examples still exist of the historical Delta ecosystem that support native species and that are functioning similarly today as they did historically. These remnants have been protected, restored and/or enhanced, and they provide examples of what restored Delta landscapes may look like:

- **Tidal wetlands** at Rush Ranch possess a largely intact prehistoric marsh form, high levels of hydrogeomorphic complexity, habitat for rare and endemic plants, and a gradual transition between the marsh and undeveloped upland grasslands (Whitcraft et al. 2011). These wetlands have branching channels that support native tidal vegetation. Although an estimated 27 percent of the current estuarine wetland plants at Rush Ranch are nonnative (Whitcraft et al. 2011), the site provides habitat for several rare plant species including Suisun thistle, Suisun marsh aster, and Jepson's Delta tule pea. Rush Ranch is owned and managed by the Solano Land Trust.
- **Riparian floodplain** at the Tall Forest on the Cosumnes River is an example of a late-successional riparian forest with a canopy height of up to nearly 100 feet. This 100-acre parcel is one of the few areas that to some extent resembles the pre-European Central Valley riparian forests. Most of the forest is about 75 years old. Over 200 bird species have been recorded in this area and a high bird-species diversity is well-documented (Nur et al. 2006). The Tall Forest is owned by The Nature Conservancy and managed by the Bureau of Land Management as part of the Cosumnes River Preserve.
- **Vernal pool grasslands** at Jepson Prairie in the northwest Delta provide an example of a Delta landscape that still has largely intact topography, hydrology, and soils. Although the upland grassland is now mostly dominated by nonnative plant species, the numerous vernal pools support a high diversity of native plant species, and provide habitat for unique, rare and imperiled plant and wildlife species, such as Solano grass, Colusa grass, the Delta green ground beetle, and Conservancy fairy shrimp. The Jepson Prairie Preserve is owned and managed by the Solano Land Trust.

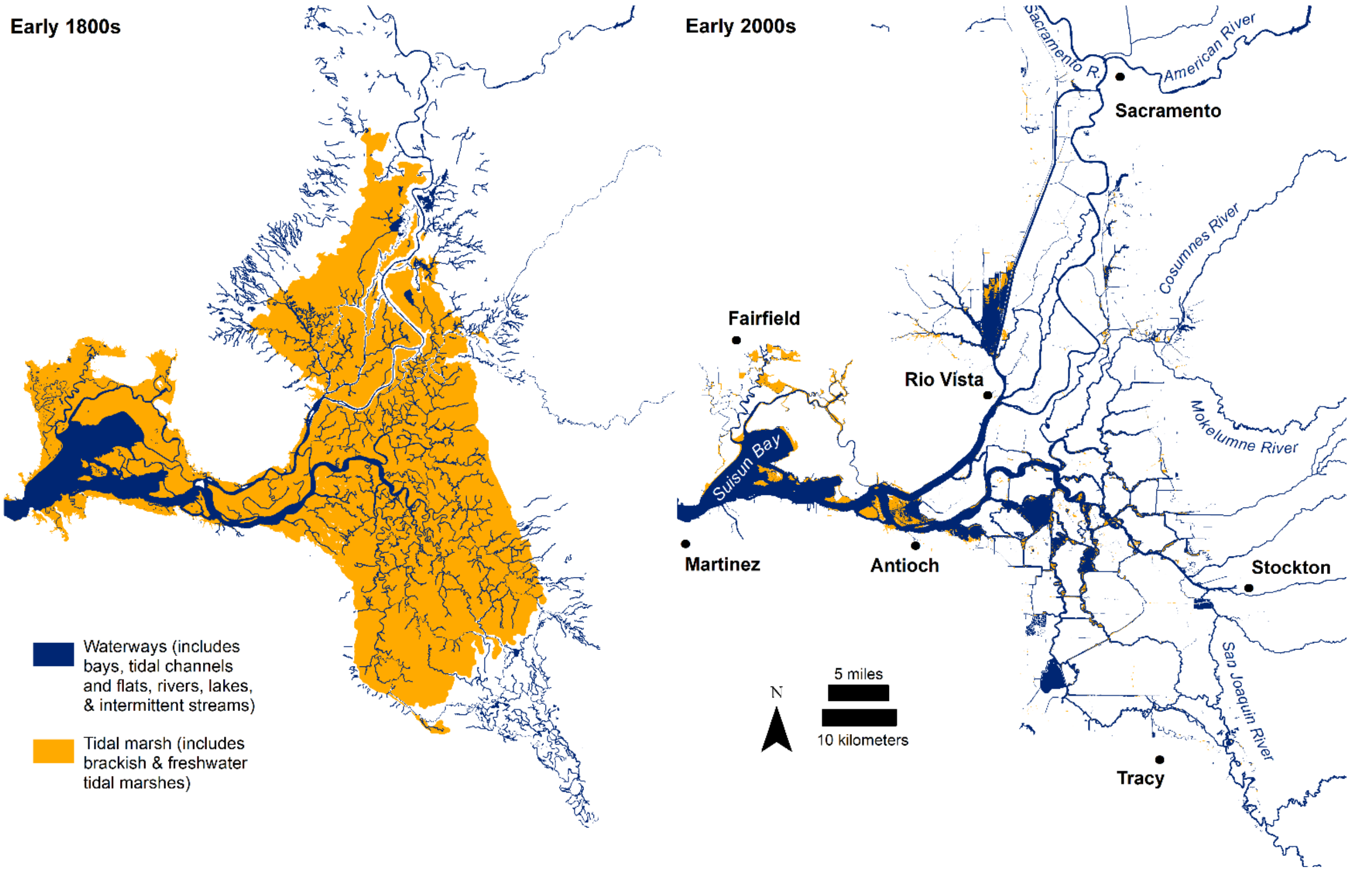

Figure 4-1. Comparison of Historical (Early 1800s) and Modern Delta Waterways

Figure 4-1 contrasts the historic extent of waterways and tidal marsh habitat in the Delta (left panel) with the modern extent (right panel). The historical map shows that through the early 1800s, rivers traversed approximately 400,000 acres of tidal wetlands and other aquatic habitats in the Delta, connecting with several hundred thousand acres of nontidal wetlands and riparian forest. The modern map shows major changes to the waterways and tidal marsh habitat, such as channel widening, meander cuts, cross levees, and loss of within-island channel networks and tidal wetlands. The historical map shows that historical tidal wetland extended over the majority of the Delta. The modern map shows that modern tidal wetland extent is limited to scattered patches, with the largest patches located in the Suisun Marsh and the western Delta.

Alternative formats of this map are available upon request.

- Source: SFEI 2012

The State of the Modern Delta

The state of the modern Delta ecosystem (mid-1800s to present) has been severely affected by loss of natural communities, loss of land-water connections, and alteration of hydrology. These stressors have caused a loss of ecosystem function, imperiling many native species and decreasing their resilience to other stressors such as nonnative invasive species, predation, and climate change. The list of endemic and native special-status species that informed the development of regional ecosystem restoration targets for this chapter is provided in Appendix Q4. Major causes for ecosystem decline discussed in this section include: large-scale conversion of wetlands to other land uses, widespread construction of levees, simplification of open water habitat, land subsidence, decline in primary productivity and food-web structure, invasive species, predation, decline of native species, and deterioration of water quality.

Loss and Modification of Natural Communities

Humans have physically transformed the Delta landscape over the past 170 years, resulting in the near total conversion of wetland, riparian, and floodplain ecosystems. Large-scale levee construction, draining of wetlands, forest clearing, and grazing began in the mid-1800s. Many of the levees were raised to keep floodwaters from entering uplands, even though the subsequent higher flood levels resulted in increased flooding of unprotected lands (Gilbert 1917). As a result, approximately 95 percent of the native ecosystems and vegetation communities were lost in the late 1800s and early 1900s (Thompson 1957, Bay Institute 1998, SFEI-ASC 2014). The loss of natural land cover has limited the capacity of the landscape to meet the life history requirements of fish and wildlife populations. The loss of riparian and wetland vegetation, and construction of fish migration barriers have significantly limited the space on the landscape which can serve as species habitat (DWR 2014, SFEI-ASC 2016).

Draining and farming the Delta's historical wetlands also exposed the Delta's peat soils to oxidation, compaction, and wind erosion, resulting in widespread land subsidence. Soil oxidation in the Delta is a major land-based contributor to carbon emissions in California (ARB 2018). Because of historic and ongoing subsidence, much of the Delta lies substantially below mean sea level—by as much as 26 feet in the interior Delta (Mount and Twiss 2005). Land elevations that are below sea level, combined with the future impacts of sea level rise, make much of the Delta vulnerable to catastrophic flooding. Current elevations also limit opportunities to reconnect historical tidal plains to channels, because wetland plants will only become established when land elevations fall within the tidal range. Many Delta islands lie well below intertidal elevation and, if flooded, would become deepwater habitat (as happened with Franks Tract and Mildred Island) instead of tidal marsh. The widespread conversion of the Delta's natural communities has had several interrelated consequences for the Delta ecosystem. Those consequences include: 1) a reduction in habitat extent, 2) loss of habitat diversity, 3) loss of connectivity within and among habitat types, 4) degradation of habitat quality, and 5) disconnection of habitats from the physical processes that form and sustain them (SFEI-ASC 2014).

Tidal wetlands in the modern Delta no longer span broad continuous gradients; instead they persist as isolated narrow patches (Figure 4-1). The small size of these existing tidal wetland patches severely limits the wildlife populations that can be supported. The few remaining wetland patches are often quite isolated from one another, creating challenges for marsh-dependent species to move between patches. The habitat quality of these marsh patches is also further degraded by the effects of invasive species, nutrient and contaminant loading, and a decline of sediment input from the upper watershed as a result of dams (SFEI-ASC 2014, Council 2018b).

The area of valley foothill riparian forest in the modern Delta has been estimated to be reduced by more than 70 percent compared to the historical Delta, consequently leading to a substantial decline of the ecological functions provided by large, interconnected riparian corridors. A key factor in the decline of riparian forests in the Delta is that they are often physically disconnected from rivers by constructed levees, and they are thereby isolated from the physical processes that created and sustained them. The riparian communities in the Delta that remain are now largely narrow, isolated patches, representing a loss in connected corridors that are important for movement and migration of many wildlife species (SFEI-ASC 2014). Wildlife living in most woody riparian patches is subjected to the effects of diminished patch size, severed connections, and increased threats from the surrounding landscape (Wiens et al. 2016).

The geometry of the Delta's main tidal channels has also been highly modified since the mid-1800s (Figure 4-1). Most of the channels in the modern Delta are lined with steep, constructed levees armored with bank protection (e.g., riprap) which isolate the channel from adjacent habitats and prevent the channel from naturally meandering and shifting course over time. The large channels of the Delta were straightened with meander cutoffs, as well as dredged and widened to facilitate navigation through the Delta. These modifications created channel networks with more homogenized abiotic conditions (e.g., salinity, temperature, nutrients, etc.) which reduced the ability for native fish to find and remain within areas with preferred habitat conditions (SFEI-ASC 2014). The altered geometry of the Delta channels also tends to flush water through the Delta more quickly, compared to historical conditions when water slowed down within highly sinuous channels and regularly overflowed laterally onto tidal wetlands and seasonal floodplains. These changes often contribute to higher average velocities and lower residence times, consequently inhibiting primary productivity of the aquatic food web.

While estuarine ecosystems are typically associated with high rates of primary productivity, a function of the variable freshwater-marine interface, the estimated amount of phytoplankton production in the modern Delta ranks among the lowest 15 percent of the world's estuaries (Cloern et al. 2014). Tidal wetlands are highly productive habitats. Dendritic channels support phytoplankton and benthic microalgae, and marsh plants provide surfaces for additional algae. Tidal marsh productivity supports benthic and pelagic food webs (Howe and Simenstad 2011, Harfmann et al. 2019), including fish that forage in shallow marsh channels, and to a lesser degree by the export of phytoplankton and zooplankton from the marsh to adjacent aquatic habitats (Herbold et al. 2014, Kimmerer et al. 2019). However, most tidal wetlands and shallow aquatic habitat in the Delta have been lost, and remaining habitats are distributed along the edges of large channels and flooded islands—adjacent to large areas of deep water—in contrast to the shallow, branching channels and tidal wetlands that characterized the historical Delta (SFEI-ASC 2014). The reduction of flow and land-water connectivity in the modern Delta, coupled with the landscape-scale loss of wetland and riparian vegetation communities, has greatly reduced the role of wetlands in supporting the Delta food web (Cloern et al. 2016).

This arrangement has created an aquatic environment with lower residence time and higher velocities of water, resulting in lower phytoplankton primary productivity and lower food web support. Lack of primary production has been identified as one cause of decline for the endangered delta smelt population (Cloern et al. 2016). The gradual transition zone between wetland and terrestrial habitats, which supported many species, has been lost. The transition zone has been replaced by fragmented and narrow patches of terrestrial habitat on the Delta's edge that provide fewer opportunities for foraging, cover, and movement of fish and wildlife species (SFEI-ASC 2014, Cloern et al. 2016).

The impact to the Delta's aquatic food web from changes in the Delta landscape has been compounded by the introduction of two nonnative invasive clam species—the overbite clam (*Potamocorbula amurensis*) and Asian clam (*Corbicula fluminea*). Both species are documented to be such effective filter feeders that they can greatly reduce phytoplankton biomass, thereby shrinking the base of the food web for the entire aquatic ecosystem. The effect of these two nonnative species is contributing to decreased populations of many previously common fish species—both native and introduced—a phenomenon known as the Pelagic Organism Decline (POD) (Sommer et al. 2007). Bivalves such as these nonnative clams also contribute to toxic accumulation of selenium in fish and diving ducks (U.S. Fish and Wildlife Service 2008, Thompson and Parchaso 2012).

Alteration of Delta Hydrology

In addition to land elevation, water flows and associated water levels are key drivers of habitat conditions and species dynamics within the Delta landscape. Within the northern, eastern, and western Delta, along the major river channels, high flows and resulting high water levels can seasonally inundate floodplains, temporarily converting terrestrial habitats into aquatic habitats. Freshwater flows are also a major source of sediment input to the system, which helps build up and maintain tidal wetlands. Additionally, flows influence salinity in the Delta, especially in the central and western Delta, which directly influences where many species are found. Flows also affect a number of other factors in the ecosystem, including dissolved oxygen, methylation of mercury, and other water quality parameters including harmful algal blooms, aquatic weed growth, and migration and distribution of fish species (see Chapter 6 for a detailed discussion of water quality issues in the modern Delta).

Delta ecosystem health is strongly tied to water supply management in the Delta watershed. The Sacramento and San Joaquin Rivers' flows are highly managed to support agricultural and urban water supply, maintain water quality, and reduce flood risk (see Chapters 3 and 7). Management practices that control releases from upstream reservoirs for water diversions and exports reduced intra-annual variability, spring outflow, and average annual outflow by approximately 48 percent between 1986 and 2005 (Fleenor et al. 2010, SWRCB 2017). Long-term flow modifications, reflected in these types of management actions, together with highly modified Delta channel geometry, have altered the seasonal flow, salinity, and sediment regimes in the Delta (Wright and Schoellhamer 2004, Enright and Culberson 2010) to the detriment of native species. Natural seasonal and year-to-year variability of river flows has given way to more stable, artificially regulated conditions.

Flows have been modified at the expense of maintaining natural estuarine processes. For example, low winter-spring flows reduce access to spawning and rearing habitats in tributaries and floodplains (Sommer et al. 1997, Feyrer 2004, Feyrer et al. 2007). In certain regions of the Delta, some native fish species use flow direction as a migratory cue at different points in their life cycle, and a change in velocity or flow reversal may lead to confusion and affect migratory patterns (Monismith et al. 2014). The dams used to regulate flows for water supply and flood management purposes also create fish migration barriers and block access to spawning areas critical to salmonids, Sacramento splittail, and other native fish, and affect water temperatures and other water quality conditions.

Less variable flow conditions also create improved habitat conditions for nonnative invasive species. Introducing nonnative species directly and indirectly affects native species populations through predation and competition for limited resources (NMFS 2009, Buchanan et al. 2013, Healey et al. 2016). While most new species introduced to the Delta system arrive unintentionally, nonnative species have also been intentionally introduced in the past. For example, many nonnative fishes were introduced into the Delta ecosystem for sport fishing, as forage for sportfish, for human food use, and due to the release of aquarium species (Moyle 2002). Nonnative invasive plants in stream channels, wetlands, and riparian areas have also contributed to losses in native species richness, ecosystem function, and habitat quality (Blank and Young 2002, Reynolds and Boyer 2010, SFEI-ASC 2014). Reduced variability of salinity has also allowed for nonnative species to thrive in areas where they were not historically dominant (Nobriga et al. 2008.) Certain portions of Suisun Marsh have retained variability of salinity, channel flows, depth and turbidity, and remain associated with much lower numbers of nonnative species (Lund et al. 2007).

In addition, flow paths through the Delta have been highly simplified because of channel cuts, channel straightening, and widening (also described as “over-connectedness”). As described previously, the altered channel geometry reduces overall residence time of tidal flow and diversity of flow patterns and water quality. The south Delta diversions also cause reverse flows in the Old and Middle Rivers, causing entrainment of fish and other aquatic organisms at the export pumps despite management by federal and state agencies (Grimaldo et al. 2009). Additional entrainment occurs in unscreened minor diversions for in-Delta water use (Moyle and White, 2002).

Although not discussed at-length in this chapter, the Delta and Suisun Marsh ecosystems are contaminated with metals, pesticides, and other legacy contaminants, as well as pollutants that have not yet been detected, such as flame retardants and pharmaceuticals (Werner et al. 2008). For more details on water quality, see Chapter 6 of the Delta Plan.

Ecosystem Resiliency and Climate Change Adaptation

Climate change will have major implications for the future of the Delta ecosystem. It will lead to increased temperatures, changing precipitation and runoff patterns, increased frequency of extreme weather events, and rising sea levels (see “Climate Change” section on page 4-15 for specifics on how climate change will influence the Delta). As described in Chapter 3, these climatic trends must be accounted for in both water management and ecosystem sustainability strategies to improve system robustness and resiliency (Jenkins et al. 2004, Opperman et al. 2009, Cahill and Lund 2013, Kiparsky et al. 2014, Null et al. 2014, Lund 2015, Dettinger et al. 2015, Dettinger 2016, Poff et al. 2016).

Although climate change will affect many of the Delta’s resources, a restored Delta can provide future climate change refugia in California’s Central Valley, buffering climate change impacts in a manner that enables the persistence of valued physical and ecological resources (Morelli et al. 2016). Because of its proximity to the ocean, the Delta is projected to be one of the coolest regions in the Central Valley, cooler than average by about 2°F (Dettinger et al. 1995, Cal-Adapt 2017). While research by Bever et al. (2018) documented recent declines in wind speeds, future inland warming may enhance the Delta’s cooling breezes (Lebassi et al. 2009). Since wetlands and riparian areas possess higher water content compared to most upland areas, they absorb relatively more heat and can buffer against extreme high temperatures (Seavy et al. 2009).

Tidal wetland restoration is expected to increase the availability and quality of food resources for native fish. Improved prey availability and diet quality can effectively increase the optimal growth temperature and thermal tolerance range for fish. Increasing the extent of riparian habitat throughout the Delta, specifically large woody riparian vegetation which overhangs and shades water from direct sunlight, would also help to lessen the effects of climate change on increasing water temperatures (Davenport et al. 2016). Additionally, riparian habitat helps to recharge groundwater, and the reemergence of cooler groundwater into warmer surface waters creates important microhabitats of cooler water temperatures (Seavy et al. 2009). The locations and extent of tidal wetlands in the Delta will inevitably shift as sea levels rise. Tidal wetlands respond to rising sea levels by accreting soil matter to build up the elevation of the wetlands. It is currently uncertain how long tidal wetland accretion rates in the Delta will be able to keep pace with future rates of sea level rise. If accretion does not build sufficient material to keep pace, wetlands can migrate to adjacent areas of higher elevation. However, in the current Delta landscape many existing wetland patches are blocked from migrating upland by levees, roadways, or other infrastructure (Orr and Sheehan 2012, Dettinger et al. 2016). Species that depend on tidal wetlands, such as the saltmarsh harvest mouse in Suisun Marsh or black rail in the Delta, are therefore at risk of losing their habitat due to sea level rise.

Climate change will have a profound impact on the landscape of the Delta and habitat conditions for species found in the Delta—including those with cultural significance for indigenous peoples, such as delta smelt, Chinook salmon, riparian brush rabbit, San Joaquin kit fox, and greater sandhill crane (Bedsworth et al. 2018). Many of these culturally significant species have already experienced great declines in population and distribution within the Delta and beyond (Hankins 2018). While the effects of climate change—due to changes in sea level, alterations in the cycles of wet and dry weather, and shifting patterns of flood and fire—have been experienced by indigenous peoples living in the Delta region for millennia, the opportunities for tribes to engage in resiliency have often been overlooked. Traditionally, such opportunities have been limited, because much of the natural habitat of the region has been heavily impacted by land-use conversion, and the wildland habitat that remains is extremely fragmented (Bedsworth et al. 2018). However, many indigenous belief systems have a common understanding that there is a reciprocity between the health of the natural landscape and cultural well-being; as such, restoration of the natural environment helps prompt cultural renewal, and cultural revitalization stimulates the push for continued protection of the natural environment (Kimmerer 2011). Restoration, enhancement and protection of the Delta ecosystem, especially in the face of climate change, promotes the long-term protection of culturally significant natural resources.

Inundation of seasonal floodplains was historically tied to large precipitation events or spring snowmelt. With climate change, floods in the Delta are likely to increase in frequency and intensity of peak flows but decrease in total duration. The construction of flood management infrastructure, such as dams, levees, and weirs, reduced floodplain inundation width and extent, increased floodplain depth, and shortened inundation duration. The vast historical floodplains of the Sacramento and San Joaquin Rivers and their tributaries provided native species with an extensive, connected landscape with opportunities to access suitable floodplain habitat and refuge from high flow conditions. With the disconnection of floodplains from channels, the access to suitable floodplain habitat has become much more limited. This limitation will be magnified with increased and more frequent flood flows resulting from climate change, making opportunities to access shallow, low-velocity floodplain habitat and refuge from high flow conditions even more limited. Reduced frequencies of long-duration inundation of the floodplain is expected to reduce the spawning success of native floodplain-dependent species like Sacramento splittail. Floodplain restoration would improve access for native species to low-velocity floodplains and flood refugia habitats, making the ecosystem more resilient to increased flooding by allowing native species to adjust to changes in water levels. Restoring seasonal floodplain functions would help to lessen the impact of more frequent extreme floods anticipated from climate change that can potentially damage downstream habitats. Further, managing floodplains as “green infrastructure” has many benefits for native species, recreation, and protection from sea level rise (Bedsworth et al. 2018).

Climate change is likely to result in salinity intrusion inland into the Delta because of sea level rise and net reductions in freshwater inflow. In addition to rising sea levels, the amount of ideal low-salinity habitat for native fish such as the longfin and delta smelts will be affected by changes in runoff timing and intensity. All of these factors will alter the location and the extent of the area in the Delta and Suisun Marsh where habitat is suitable for fish species with specific salinity needs or tolerances.

Native fish species which require cold water (below 71.6°F) may suffer as a result of climate change as water temperatures rise, because they exhibit lower physiological tolerances for elevated water temperatures compared to nonnative fish species introduced from areas where temperatures are warmer than those found in the Delta (Davis et al. 2019). Restoration planning may warrant opening up more downstream (seaward) habitat, where water temperatures are naturally cooler and could potentially be less favorable to nonnative fish that have limited tolerance for higher salinity (e.g., largemouth bass). Maintaining the viability of Chinook salmon and steelhead in Central Valley rivers in the face of climate change may require re-establishing connectivity to cold water habitats in upper watersheds that are currently blocked by major dams since there may be less future flexibility to operate reservoirs to manage flow releases that protect downstream populations of native fish. Larger storms may force flow releases for flood safety purposes and smaller winter snowpacks caused by warmer, wetter winter storms may reduce the ability to replenish reservoirs during the dry season.

Warmer water temperatures may prompt more frequent harmful algal blooms (HAB) of the cyanobacteria *Microcystis aeruginosa*, which produces toxins harmful to fish (Lehman et al. 2013, SWRCB 2016; other impacts of HABs are discussed in Chapter 6). It is also expected to lead to more rapid growth of certain undesirable nonnative plants, such as water hyacinth, which grows more rapidly in warmer temperatures. Warmer temperatures may increase the concentration of mercury in the food web through accelerate mercury methylation, algal photosynthesis, and consumption rates (Alpers et al. 2008). For land-based wildlife and vegetation communities, higher air temperatures could lead to drier soil conditions, change plant community composition, and even disrupt timing between pollinators and plants. Past modifications and ongoing stressors have reduced the resilience of the Delta ecosystem and limited its ability to adapt to the anticipated effects of climate change.

CLIMATE CHANGE

The effects of climate change will have major implications for the future of the Delta ecosystem. Climate change is expected to have the following four effects on the Delta ecosystem: increased temperatures, altered precipitation and runoff patterns, increased frequency of extreme weather events, and sea level rise. The timescale on which these changes could occur depends on numerous factors, and may accelerate under global scenarios involving ice-sheet loss or permafrost thawing. The implications for the Delta ecosystem are summarized below:

Increased Air and Water Temperatures

- Increased moisture loss from evaporation and transpiration by plants, contributing to decreased river inflows, especially during summer
- Increased frequency of summer heat stress on cold water-adapted species
- More hospitable habitat for nonnative species adapted to warmer climates

Altered Precipitation and Runoff Patterns

- Runoff earlier in the wet season, and decreased dry-season flow from reduced snowpack
- Decreased duration of peak flows
- Reduced occurrence of long-duration seasonal floodplain inundation

Increased Frequency of Extreme Weather Events

- Increased frequency of larger, warmer storms
- Increased frequency of floods and droughts
- Increased sedimentation from extreme flood events and decreased water quality during droughts

Sea Level Rise

- Increased tidal water levels
- Increased salinity intrusion into the Delta
- Reduction in freshwater Delta habitat and an increase in saline Delta habitat
- Reduced growth rate of submerged vegetation

A Call for Action

The rapid and drastic transformations of the Delta landscape and its watershed have had significant effects on the native fish and wildlife species within the Delta. These modifications include agricultural and urban development, channel modification, and construction of levees and water management infrastructure. Other factors have, in turn, contributed to ongoing stressors, such as the proliferation of nonnative species in the Delta and Suisun Marsh, mercury methylation, pesticide and toxin contamination, nutrient loading, and altered flows. Still other factors are expected to increase stress on the Delta in the future, such as new and emerging contaminants, sea level rise, increased variability in hydrology, and other consequences of climate change. These changes demand that habitat restoration focuses on providing greater habitat resiliency, allowing native species to maintain thriving populations in the face of these environmental changes.

Although projects are underway to partially alleviate some of these stressors (e.g., improved wastewater treatment at the Sacramento Regional Wastewater Treatment Plant and large-scale habitat restoration projects), the challenges faced by the Delta's native species are expected to continue into the foreseeable future. More than 230 species within the region are special-status species (DWR 2013a). Large-scale habitat loss or degradation likely has resulted in extirpation of regional native species populations from the Delta, such as the Sacramento perch (Moyle 2002), and especially of species that are habitat specialists; while some species have experienced precipitous population declines and could face extinction in the wild (e.g., delta smelt and winter-run Chinook salmon). This has led to protections for scores of plant and wildlife species under federal and state laws and regulations. Past species-specific conservation efforts (e.g., what has largely occurred with implementation of the federal Endangered Species Act) have been extremely effective at preventing extinction of species placed under protection, but limited in prompting recovery of these same species (Taylor et al. 2005, Schwartz 2008). In recent decades, the focus of conservation efforts has broadened beyond single-species management to specifically considering benefits of managing entire communities and ecosystems for broader benefits (Gray et al. 2019, Mount et al. 2019).

As described in Chapter 3, there are conflicts between water operations for ecosystem management (temperature and flow variability), water quality (both in-Delta and for water exported from the Delta), and water supply reliability. These conflicts are magnified during critically dry periods and periods of lower flow—when the ecosystem is already stressed, and water suppliers are most vulnerable to shortages. Implementation of Delta Plan recommendations related to improved water conveyance and storage infrastructure and operational flexibility (addressing the timing of water movement through the Delta), combined with investments in regional self-reliance, are important parts of the portfolio of actions needed to support ecosystem restoration in the Delta.

A key component of effective restoration is reestablishing fundamental physical processes (e.g., geomorphic, chemical) which are key drivers of ecological functions such as vegetation succession or food-web function (Larsen and Greco 2002, Greco et al. 2007, Cloern et al. 2016). Reestablishing both physical and biological processes is commonly termed *process-based restoration*, and it is key to the composition and structure of vegetation communities and meeting habitat needs of sensitive species. In areas where process-based restoration is not feasible (e.g., deeply subsided areas of the Delta), there can be opportunities to enhance conditions on working landscapes, such as farmland, to benefit certain native species. For example, flooding grain crop residues during the winter, following harvest, and establishing managed wetlands for roosting on portions of agricultural properties, can produce beneficial habitat conditions for wintering sandhill cranes.

Within the restoration science community there is an emerging emphasis on the importance of implementing process-based restoration because such actions address the fundamental causes of degradation of the ecosystem, rather than the symptoms (Beechie et al. 2010, Greco 2013, Wiens et al. 2016). Part of the motivation for that shift is a recognition that past restoration actions relied too heavily on engineered solutions to provide specific habitat features for particular species (e.g., placing gravels in reaches to expand salmon spawning habitat) and often provided limited benefits because they ignored larger environmental drivers (e.g., the reason why the reach did not already have spawning gravels) (Beechie et al. 2010). Process-based restoration requires input from experts in a wide array of science and engineering disciplines (such as hydrology, geomorphology, geology, and botany). Active adaptive management that incorporates explicit experimentation should be a key component of process-based restoration projects. Although restoration in the Delta has been planned for decades, implementation of large-scale, process-based restoration projects has only been initiated recently, which underscores the importance of monitoring and adaptively managing those projects.

The Delta Reform Act requires that the ecosystem be protected, restored, and enhanced in a way that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place (California Water Code section 85054). Discussions regarding the future management of the Delta have often been unproductive because of a perceived conflict between social and ecological objectives, due to differing cultural perspectives on the value of nature (Milligan and Kraus-Polk 2017). While some perspectives believe that nature should be protected simply because it has intrinsic value, or because there is a sacred or cultural connection with the land (Yocha Dehe Wintun Nation 2015), others, such as utilitarian perspectives, only value the raw materials and resources that can be extracted from nature. Yet even utilitarian perspectives must recognize that the natural environment produces tangible social benefits, and that humans depend directly on the biological integrity of our natural landscapes to provide ecosystem services (Costanza et al. 1997, Postel and Carpenter 1997). Ecosystem services are the economic benefits that society derives from ecosystem processes, including pollination (which supports food production), primary production (which supports fisheries), soil formation (which builds land elevation and sequesters carbon), and water storage and regulation (which can mitigate flood peaks) among other relationships (Costanza et al. 1997). The Delta's agricultural economy, and cultural and recreational traditions, depend on these processes derived from the continued functioning of the Delta and its connected ecosystems. The meaningful benefits that society gains from a healthy ecosystem should inform decision-making concerning tradeoffs between land use and economic growth (Suding et al. 2015, Wiens et al. 2016).

A portfolio of approaches is necessary to manage ecosystems in highly altered and changing landscapes (Hobbs et al. 2014). These approaches include protecting existing ecosystems, restoring ecosystems, and enhancing working or urban landscapes that provide habitat resources to select species (Bay Institute 1998, Moyle et al. 2012, SFEI-ASC 2016). These approaches have varied potential to reestablish ecological processes in natural communities at a sufficient scale (and with connectivity, complexity, and diversity) to be resilient to land conversion and climate change. Given the urgency to improve the ecosystem, restoration should be prioritized in locations where it is possible to restore ecosystem function, while ecosystem protection and enhancement activities continue in other locations (Appendix Q3). Restoration involves the process of assisting the recovery of an ecosystem that has already been degraded, damaged, or destroyed, and works in tandem with ecosystem preservation by expanding ecological functions of the preserved ecosystems (Society for Ecological Restoration International 2004, McDonald et al. 2016). Whether implemented as the primary purpose of a project or as mitigation, restoration activities should be planned and designed to contribute effectively to restoring ecosystem function within the Delta.

Vision for a Restored Delta Ecosystem

Achieving the coequal goal of ecosystem protection, restoration, and enhancement means successfully establishing a resilient, functioning estuary and surrounding terrestrial landscape capable of supporting viable populations of native resident and migratory species with diverse and biologically appropriate habitats, functional corridors, and ecosystem processes. Ecosystem function, in this context, represents the full range of physical and biochemical processes that sustain an ecosystem over time and space (Naeem and Wright 2003), including the processes that sustain a native species assemblage in a particular area over time. Ecosystem functions include not just biological processes, such as biomass production, food web support, and biodiversity support, but also biogeochemical processes, such as nutrient cycling.

The Delta Reform Act’s definition of restoration recognizes that the ecosystem will be dynamic, changing in response to restoration actions and future climate change (California Water Code section 85066, Healey et al. 2008, Delta ISB 2011).

The Delta Reform Act calls for the Delta Plan to provide a long-term vision for restoring interconnected habitats within the Delta and its watershed by 2100 (California Water Code section 85302[e][1]). The Council envisions a future in which the Delta ecosystem has the following characteristics:

- Native species, including algae, plants, invertebrates, fish, birds, and other wildlife, are self-sustaining and persistent.

- The tidal channels and bays in the Delta and Suisun Marsh connect with tidal wetlands, freshwater creeks, upland grasslands, and woodlands. The Sacramento and San Joaquin Rivers and other Delta tributaries include reaches where streams are free to meander and connect seasonally to functional floodplains.
- Habitats for native resident and rearing migratory fish, birds, and upland wildlife are connected by aquatic and terrestrial migratory corridors, including areas with high-quality plant cover and feeding opportunities.
- More natural variations in water flows and conditions make aquatic habitats, tidal wetlands, and floodplains more dynamic; encourage survival of native species; and resist invasions by weeds and animal pests.
- The ecosystem is resilient enough to absorb and adapt to current and future effects of multiple stressors without significant declines in ecosystem services.
- The Delta will provide more reliable water supplies, in part because survival of its wildlife, fish, and plants do not require extraordinary regulatory protection (e.g., federal or California Endangered Species Act protection).
- Californians recognize and celebrate the Delta's unique natural resource values through wildlife observation, angling, waterfowl hunting, and other outdoor recreation.

A restored Delta ecosystem depends on a future in which large-scale interconnected natural communities, characterized by land-water connections and natural vegetation, support productivity and diversity of native species that persist over long periods of time. This occurs at a scale needed to meet or exceed the goals in existing species recovery plans and state and federal goals with respect to doubling the population of salmon (California Water Code section 85302[c][5]). Restored habitat and agricultural landscape elements will coexist within an evolving landscape whose course of gradual change depends on their location. This vision depends on effective contributions from all restoration activities, including mitigation and recovery plans. Currently 14 recovery plans, conservation strategies, and species-specific resiliency plans provide specific guidance on the level of ecosystem restoration needed (Council 2018a, Appendix Q4). These strategies and plans collectively address 121 of the most imperiled species, and considered together, provide the best available understanding of an ecosystem-based restoration target (PPIC 2013). It is currently estimated that it will take approximately 60,000-80,000 acres of net new functional, diverse, and interconnected habitat to achieve the fully restored Delta landscape envisioned in the Delta Reform Act (see Appendix E, PM 4.16) or roughly 7 to 10 percent of the combined land area of the Delta and Suisun Marsh. This estimate is comprised of multiple landforms and vegetation communities, and is based on a review of current planning and management efforts, including recovery plans, conservation strategies, and species-specific resiliency plans intended to benefit conditions for native species found in the Delta.

The future Delta will differ both from the Delta that was known to the region's first inhabitants, and from the current ecosystem. Not every native species or natural area now found in the Delta may persist through the changes ahead, including climate change. The survival and recovery of native species, and the level of benefits provided by the Delta ecosystem, are dependent in part on the actions that Californians are willing to take to restore the Delta ecosystem.

WHAT COULD A RESTORED DELTA LOOK LIKE?

The Delta Reform Act calls for the Delta Plan to provide a long-term vision for restoring interconnected habitats within the Delta and its watershed by 2100 (California Water Code section 85302[e][1]). But this vision, and how it is achieved, may vary within different regions of the Delta.

The Cosumnes River Preserve, which partially overlaps with the northeastern portion of the Delta, provides a case study for the potential outcome of a concerted effort to preserve and restore large patches of natural lands over the course of multiple decades. The Nature Conservancy and Ducks Unlimited established the Cosumnes River Preserve in 1987 to protect more than 1,000 acres of riparian habitat along the Cosumnes River corridor, which has uniquely large stands of remnant valley oak riparian forests and an intact flow regime. The Preserve now consists of over 50,000 acres of wildlife habitat and agricultural lands that are owned by seven different Preserve Partners: U.S. Bureau of Land Management (BLM), California Department of Fish and Wildlife, California Department of Water Resources, California State Lands Commission, Sacramento County Regional Parks, The Nature Conservancy, and Ducks Unlimited. The long-term vision of the partnership is to establish the permanent protection of a continuous riparian corridor extending from the Cosumnes River headwaters to the Delta, including adjacent floodplain and wetland habitats and a vast vernal pool grassland complex.

The Preserve Partners work together to implement conservation measures that preserve and restore natural lands in a manner that integrates agricultural lands and practices. Six of the Preserve Partners are signatories to a Cooperative Management Agreement, which defines the process through which they coordinate ownership and management activities, and the authority each has to do so. For example, the Cooperative Management Agreement commits the BLM to providing a wetland manager position and a preserve manager position to coordinate all restoration and land management activities, funded jointly by multiple Preserve Partners. Much of the area along the lower 14 miles of the Cosumnes River is protected within the Cosumnes River Preserve, including approximately 70 percent of the existing riparian forest, and about 45 percent of the total existing and restorable riparian habitat. Many of the habitat improvements along the Cosumnes River have resulted from a combination of significant levee breaches that have occurred both naturally or intentionally. For example, in 1985, flooding resulted in an unintended breach of a levee two miles downstream of Twin Cities Road. The breach resulted in a substantial deposition of sand onto the floodplain and in the establishment of the "accidental forest" which now consists of a rich mosaic of riparian trees. Over time, the Cosumnes River Preserve partners have also conducted intentional breaches of levees to achieve similar results. More recent efforts have focused on restoring tidal wetlands and seasonal floodplains within the lower Cosumnes River, including the Cougar Wetland Restoration Project, the Grizzly Slough Restoration Project, and the McCormack-Williamson Tract Project.

The levee breaches reestablished the connection between channel and floodplain, which, because the Cosumnes River is not regulated by a major dam, has restored the ecological processes of sediment deposition and riparian plant community colonization; allowing native fish species to utilize floodplains and neotropical song bird species to colonize the newly established riparian habitat.

Figure 4-2. Simulation of Restored Future Delta Landscape

- This figure is a simulation of what a restored future Delta landscape might look like. It shows an aerial view of an agricultural landscape interspersed with riparian forest and floodplains that are connected to river channels.
- Source: SFEI-ASC 2016

Core Strategies

The Delta Reform Act calls for the Delta Plan to include strategies to assist in guiding state and local agency actions related to the Delta (California Water Code section 85300[a]). The core strategies described below take a balanced approach to ecosystem protection, restoration, and enhancement by identifying changes that are required of the physical environment to reestablish ecological processes, at large scales, and within complex and diverse natural communities that are connected across the landscape, and that are resilient to threats associated with climate change and other factors. These strategies are interconnected and support one another; they should be implemented in combination with each other to make progress in achieving the objectives for the Delta ecosystem set forth in the Delta Reform Act.

The core strategies describe how successful implementation of restoration actions depends on the ability of local, state, and federal agencies, as well as stakeholders, to coordinate and align activities. The five core strategies described in this section leverage decades of research, recovery planning, and restoration activities to lay out a path forward, increasing coordination and working towards a common vision for a restored Delta ecosystem.

Core Strategy 1: Create More Natural, Functional Flows

The native plant, fish, and wildlife communities of the Delta evolved in response to natural flow patterns shaped by seasonal and inter-annual variation in streamflow. In estuaries, the interaction of river flows and ocean tides produces a salinity gradient from fresh water to brackish and salty water. River flows and ocean tides also deposit and erode sediment to shape the estuarine landscape and its habitats. Alterations of flow and reductions in land-water connection have altered these biological and geomorphic processes, negatively impacting the Delta's natural communities.

In tributaries and floodplains, low winter and spring flows reduce access to fish spawning and rearing habitats (Sommer et al. 1997, Feyrer 2004, Feyrer et al. 2007). Rapid declines in spring flows can also reduce successful recruitment of riparian trees and disrupt successful rearing of fish (The Nature Conservancy et al. 2008). Low winter and spring flows limit seed dispersal to low-elevation floodplains, where elevated summer flows inhibit seedling survival (Fremier et al. 2008, The Nature Conservancy et al. 2008).

Within Delta channels and sloughs, low flows, combined with pumping at the federal Central Valley Project (CVP) and State Water Project (SWP), create reverse channel flows (i.e., net flows traveling upstream) that can create migratory confusion in some species (Monismith et al. 2014). When flow diversions occur simultaneously with certain fish life cycles, fish mortality due to entrainment may increase (Zeug and Cavallo 2014). Native fish in the Delta are more vulnerable to entrainment during winter and spring months, during their spawning and recruitment periods, though flow management and salvage mechanisms can reduce this effect (Grimaldo et al. 2009).

Delta outflow is also affected by flow alterations, including both upstream and in-Delta diversions. Outflow variability is recognized as a key factor promoting diverse native fish communities (Moyle and Mount 2007, Moyle et al. 2010). Modern water management practices have led to more stable hydrological conditions that are harmful to native species and conducive to certain nonnative species.

Restoring Delta flows and channels is one of the Delta Reform Act’s subgoals to support a healthy ecosystem (Water Code section 85302[e][4]). While it is not feasible to replicate natural flows or the natural landscapes on which those flows interacted in deeply subsided regions of the Delta, it is possible to provide more natural functional flows, in coordination with habitat restoration, to support a resilient ecosystem (SWRCB 2017). Restoring flows to meet the natural history requirements of native species requires managing flows in a manner that mimics the historical natural hydrograph, such that rivers provide the functions that species require throughout their life cycle. This “functional flows” approach relies on a scientific understanding of how changes in the timing, duration, magnitude, and frequency of flows affect the surrounding landscape and the species that rely on it, such as large floods that scour and maintain channels; flows that create and maintain floodplain connectivity that supports spawning, food production, and rearing; and predictable rates of decline in flow resulting from snowmelt recession (Yarnell et al. 2015, Poff 2017). The functional flows approach highlights the necessity of providing flows that have sufficient magnitude, duration, and frequency and appropriate timing to affect river geomorphology, promote native species, and drive ecosystem processes (Figure 4-3, Yarnell et al. 2020). Over time, this approach can address ecological trade-offs by building flexibility into the system and taking advantage of different water year types (Alexander et al. 2018).

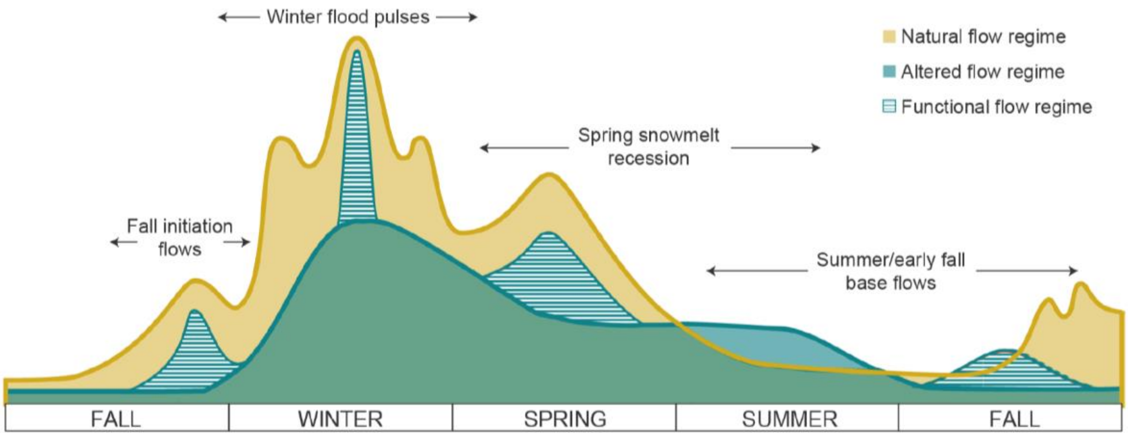

Figure 4-3. Comparison of Natural, Altered, and Functional Flow Regimes

- This figure illustrates functional flows that have sufficient magnitude, duration, frequency, and timing to affect river geomorphology, native species, and ecosystem processes. The solid beige areas illustrate a hypothetical unimpaired flow regime. The solid green areas illustrate how flow alterations such as water storage and diversion create more stable flows that do not have the characteristics needed to support geomorphic and ecosystem processes. The hatched blue areas depict flow augmentation through releases from storage or reduced diversions to mimic key elements of the natural flow regime.
- Source: Mount et al. 2019. Reprinted with permission from the Public Policy Institute of California (PPIC).

KEY COMPONENTS TO A FUNCTIONAL FLOW APPROACH

Recent research (Yarnell et al. 2015, Yarnell et al. 2020) identifies five key components of flow regimes that comprise a functional flow approach: 1) wet-season initiation flows, 2) peak magnitude flows, 3) spring recession flows, 4) dry seasonal low flows, and 5) interannual variability. Each of these components is described briefly, below.

1. **Wet Season Initiation Flows**. The timing of first increased flows of the wet season, which coincide with storm events in the late fall to early winter period within the Delta watershed, functions to signal the start of an annual shift in riverine conditions. The magnitude of these initiation flows should be able to reestablish connectivity with the riparian zone and to flush out organic matter accumulated in the channel substrate (Yarnell et al. 2015). The first pulse of these increased flows often has higher suspended sediment concentrations because sediment on hillsides and in channels is flushed downstream. This sediment pulse is often an important life-history cue for species (e.g., delta smelt spawning migration). Altering the timing of, or eliminating, this key flow event can be detrimental to the life-history strategies of native species (Yarnell et al. 2015).
2. **Peak Magnitude Flows**. High-magnitude peak flows during the flood season transport a large proportion of a river’s annual sediment load and help to restructure the channel and floodplain. These processes are important to trigger a reset in natural processes, such as scouring vegetation that has encroached in the channel, dispersing seeds and fragments of riparian vegetation, enhancing channel and floodplain variability by redistributing sediment, and eliminating nonnative species that are not adapted to such a disturbance regime. Large-magnitude peak flows also facilitate inundation of seasonal floodplains and backwaters for a duration long enough to allow for blooms of phytoplankton, and in turn zooplankton, and successful spawning by floodplain-dependent species.
3. **Spring Recession Flows**. The transition from high flows to seasonal low flows is an important life history cue for many native aquatic species. Gradually receding flows can also be important in redistributing sediments mobilized by high peak flows. They allow for continued sediment movement in deeper channels and gradual deposition within shallower areas. The gradual recession from high flows to low flows also supports completion of biological processes, such as hatching of fish and amphibian eggs in shallow water areas, or germination of riparian plants, before the waters completely recede and the habitat dries out.
4. **Dry Season Low Flows**. A period of seasonal low flows is important to promote habitat variability. Native species which have evolved in the highly variable inter- and intra-annual hydrologic regime that is so common in California are at an advantage compared to nonnative species introduced from systems with more stable conditions. If flows stay constant for too long, it can lead to silt accumulation in the channel bed and less complex channels with a reduced diversity of structural features preferred by native fish and other aquatic organisms.
5. **Interannual Variability**. Variability in the magnitude, timing, and duration of peak and low-flow events regulates aquatic food webs and supports riparian vegetation recruitment and succession. Native aquatic and riparian species are adapted to interannual variability of flows, which supports greater species diversity and resilience to continued alterations in land uses and changing climate conditions. (The Nature Conservancy et al. 2008, Kiernan and Moyle 2012).

More natural flow patterns will not provide all functions in a channelized and leveed landscape that would be supported in a restored landscape because some functions require that flow connect to and interact with land to create floodplain habitat and support aquatic primary production. Management of flow patterns can provide enhanced benefits by working in tandem with habitat restoration to produce diverse and interconnected food webs, habitat structure and refuge options, and spawning habitat (SWRCB 2017). The large-scale approach to restoration of land-water connections described in Core Strategy 2 would improve the effectiveness of more natural, functional flows in recovering special-status species that depend on wetland and floodplain habitat. As described by the Delta Independent Science Board (ISB), “flow is but one factor affecting fishes” (Delta ISB 2015). As such, a functional flows approach needs to consider the various components which make up flow, and to evaluate how those flows interact with other environmental factors in particular habitat. The functional flows should be based on flow criteria that are established to support the biological needs of flow-dependent ecosystems and species (Wilson and Dibble 2010). These factors must be balanced when developing regulatory flow objectives for individual waterways, to address unique hydraulic characteristics, public trust values, and other beneficial uses of water.

Development, implementation, and enforcement of new and updated flow objectives for the Bay-Delta and its tributaries are key to achieving the coequal goals.

Implement and Regularly Update Flow Guidance

Effectively managing flows to both restore the Delta ecosystem and improve water supply reliability is challenging, because flow-related stressors are likely to increase as the population grows and the climate changes. The State Water Resources Control Board (SWRCB) is responsible for preserving, enhancing, and restoring the quality of the state’s water resources for the protection of the environment, public health, and beneficial uses. Under this responsibility, the SWRCB prepares and updates the Bay-Delta Water Quality Control Plan (Bay-Delta Plan), which identifies beneficial uses of water, establishes water quality and flow objectives needed to protect those uses, and establishes a program of implementation for achieving the objectives (SWRCB 2019).[1]

Delta Plan regulations require covered actions that could affect flow in the Delta to demonstrate consistency with the Bay-Delta Plan flow objectives (see Ecosystem Restoration Policy [ER P1]). The objectives included in the Bay-Delta Plan are largely flow-dependent and are primarily implemented through water rights and associated conditions on water project operations.

The Bay-Delta Plan’s program of implementation includes actions by other entities, including habitat restoration and other nonflow actions, which are needed to protect beneficial uses of water. The SWRCB does not have direct regulatory authority over all of these actions, but encourages management strategies, such as voluntary agreements, that include a combination of flow and nonflow actions. Voluntary agreements that provide for reasonable

[1] The Central Valley and San Francisco Bay Regional Water Quality Control Boards also maintain water quality control plans for the Bay-Delta watershed to address other water quality parameters.

protection of beneficial uses of water could be considered and approved by SWRCB in the update and implementation of the Bay-Delta Plan.

Pursuant to state and federal requirements, the SWRCB periodically updates the Bay-Delta Plan as needed for the reasonable protection of beneficial uses of water, based on best available science. Past scientific studies have identified the biological needs of the Delta at up to 80 percent of unimpaired flows (Richter et al. 2011). Subsequent work to balance biological needs with all other beneficial uses proposed a range of 35 to 75 percent of unimpaired flows, generally not allowing for flows lower than existing conditions (SWRCB 2017). While the Council does not have a direct role in updating the Bay-Delta Plan, the Delta Science Program advises the SWRCB regarding best available science and adaptive management related to Delta flow objectives, primarily by facilitating independent advisory and review panels (see Ecosystem Restoration Recommendation [ER R]1).

As described above, flow interacts with the surrounding landscape and affects native species habitat. Therefore, several Delta Plan regulatory policies and recommendations promote protecting, restoring, and enhancing riparian floodplains and tidal wetlands in a manner that allows space for flows to access them. Ecosystem protection, restoration, and enhancement projects, including mitigation, resulting from potential voluntary agreements may be covered actions required to demonstrate consistency with applicable Delta Plan policies, including a demonstration of the use of best available science.

Through a combined effort to create more natural, functional flows and restore land-water connections in low-lying areas in the Delta, floodplain and tidal wetland habitats can support recovery of native species and potentially improve water supply reliability. This means that the frequency and duration of inundation in the Yolo Bypass would be sufficient to support native migratory fish spawning and rearing; that pulse flows on the Sacramento River would be large enough, and the recession rate slow enough, to support habitat formation and maintenance; and that more natural functional flow patterns would be created, allowing for natural variability in water year types (Figure 4-3, above) (see Appendix E, PM 4.2). When management actions use functional flows that reflect natural variability, efforts to create a more reliable water supply can work together with ecosystem protection, restoration, and enhancement.

Core Strategy 2: Restore Ecosystem Function

The Delta Reform Act specifies a subgoal to restore large areas of interconnected habitats within the Delta and its watershed by 2100 (California Water Code section 85302[e][1]). The Delta Reform Act identifies diverse and biologically appropriate habitats and ecosystem processes, functional corridors for migratory species, and viable populations of native species as characteristics of a healthy Delta ecosystem (California Water Code section 85302[c]). The Delta Reform Act requires that the Delta Plan include measures to promote conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations (California Water Code section 85302[c][5]). An evaluation of existing species recovery plan and conservation plan targets indicates that it will be necessary to reestablish tens of thousands of acres of functional, diverse, and interconnected habitat (Council 2018a, Appendix Q4). The magnitude of this need dictates a change in existing approaches to protecting, restoring, and enhancing the Delta ecosystem.

Although implementing the Delta Plan will help to achieve the specific objectives set forth in recovery plans and the salmon doubling goal, the Delta Plan is not intended to be constrained by or limited to objectives that focus only on a subset of the Delta's native species. Restoring ecosystem functions by establishing large areas of interconnected habitat—along with the other four strategies identified in this chapter—will help increase the likelihood that the objectives of recovery plans and salmon doubling are met (see Appendix E, PM 4.6), and will also benefit a broader array of native Delta species.

Decades of efforts aimed at improving aquatic and terrestrial ecosystems of the Delta and Suisun Marsh have failed to prevent declining species populations. Many of these efforts are limited to single-species conservation, recovery, or mitigation projects. Best available science supports an emphasis on restoring ecosystem function over single-species management (SFEI-ASC 2016, Council 2018a). However, agencies charged with stewardship and restoration of the Delta ecosystem have limited ability to change these practices due to permitting requirements and restrictions on the amount and use of public funds. Information gaps also prevent more systematic planning and adaptive management of these activities and investments (additional information is discussed in Core Strategy 5). Ecosystem protection, restoration, and enhancement are not just about adding up the acres of restored habitat, but also about landscape-scale ecosystem attributes, such as connectivity, complexity, diversity, and scale (SFEI-ASC 2016).

Priority Attributes

The Delta ecosystem is naturally dynamic in response to a variable climate and variable river flows. A sustainable Delta ecosystem needs to be large, diverse, and structurally complex in order to accommodate this variability and sustain native species communities. Best available restoration science identifies the following priority attributes that maximize the effectiveness of individual ecosystem protection, restoration, and enhancement projects:

1. restore hydrological, geomorphic, and biological processes
2. be large-scale
3. improve connectivity
4. increase native vegetation cover
5. contribute to the recovery of special-status species

Each of these attributes is discussed below. Additional information is provided in Appendix Q2; see also regulatory Appendix 3A.

Restore Hydrological, Geomorphic, and Biological Processes

Ecological processes consist of the physical, chemical, and biological processes that connect organisms and their environment, such as nutrient cycling, erosion, sedimentation, and accretion. Reestablishing these processes requires reestablishing land-water connections (e.g., floodplains, river channels, tidal channels, and marsh plains). Ecological processes function to sustain the natural ecosystem, including its native species, communities, and habitats within the Delta over time (Beechie et al. 2010, Greco 2013, Wiens et al. 2016).

Be Large-Scale

The ecological processes described above occur over varied scales and time periods (Palmer et al. 2016, SFEI-ASC 2016). Larger-scale protection, restoration, and enhancement projects implemented over long periods of time can accommodate ecosystem processes more effectively, compared to small-scale projects. (Kauffman et al. 1997, Simenstad et al. 2006, Opperman 2008). Similarly, larger-scale projects are expected to create natural systems that are more capable of sustaining desired functions in uncertain future environmental conditions (Peterson et al. 1998, SFEI-ASC 2016).

Improve Connectivity

Connected habitats are important for sustaining species populations and biological diversity across increasingly fragmented landscapes. Connectivity requirements are specific to each species and how it uses the landscape. For example, certain mammal species may require adjoining corridors of suitable habitat to be able to move from one area to another. By contrast, habitat patches separated by miles are functional connections for many bird species. Various aspects of connectivity are crucial to riparian and wetland systems' ability to support biodiversity (Vannote et al. 1980, Poff et al. 1997). This heightens the importance of such ecosystems, in light of ecological adaptation and a rapidly changing climate (Naiman et al. 1993, Seavy et al. 2009, SFEI-ASC 2016).

Increase Native Vegetation Cover

The loss of native vegetation cover has greatly reduced habitat complexity in the Delta over the last 160 years, completely altering aquatic and intertidal food-web dynamics (Moyle et al. 2010, Whipple et al. 2012). Restoration of complex ecosystems will require reestablishment of native vegetation communities, and the underlying processes that support their recruitment, disturbance regimes, and community succession. Restoring a variety of native vegetation cover types can promote ecological resilience and enhance native biodiversity by providing a range of habitat options for species, thus expanding the types and numbers of species that a landscape can support.

Contribute to the Recovery of Special-Status Species

Many native plant, fish, and wildlife species in the Delta are imperiled by human activities, and have varying degrees of risk of elimination from the Delta landscape or outright extinction. Habitat loss and degradation and the resulting impacts on food-web dynamics have been a major cause of the special status of these species (Suding 2011, Palmer et al. 2016). Restoring ecological functions is an important requirement for the recovery of these species.

Improve Project Design

Ecosystem protection, restoration, and enhancement actions that have all five priority attributes will be most effective in restoring ecosystem function. Actions with only one or two of these attributes would be less effective, although they would still contribute toward the goal.

In locations where conditions in the landscape allow for ecosystem protection, restoration, and enhancement actions that would achieve most, if not all, of the priority attributes, the focus should be on ensuring that such projects are designed to achieve as many of these attributes as feasible. It is inappropriate to implement ecosystem protection, restoration, or enhancement actions (whether for mitigation, recovery, or other objectives) that can only achieve one or two of the priority attributes in locations that could potentially support four or more of these attributes, since such areas are extremely limited within the Delta. Areas of the Delta that can only support projects that achieve one or two of the priority attributes are much more commonplace (e.g., areas which are too subsided to ever support tidal wetland restoration). The incremental benefits to ecosystem function achieved by implementing a singular action with a very limited number of the priority attributes may be modest, but given that there are ample opportunities to implement these actions throughout the Delta, wide-scale implementation of such projects can make meaningful contributions to ecological functions.

Certifications of consistency for all covered actions that consist of or include components of environmental protection, restoration, or enhancement—including implementation of recovery plans and mitigation projects—must demonstrate that the covered action has one or more of the five priority attributes (see New ER Policy “A”). There are several examples of restoration projects that include restoration of ecological processes, and all or most other priority attributes. These include the Dutch Slough Tidal Marsh Restoration Project, the West Sacramento Southport Setback Levee Project, and the Lindsey Slough Tidal Marsh Restoration Project. Each of these projects is large-scale and has been designed to restore land-water connections, improve habitat connectivity, reestablish native vegetation communities, and benefit special-status species. Planning and implementation of these projects required collaboration among multiple jurisdictions, and support from multiple funding sources. Continued progress toward projects that restore ecological processes and most other priority attributes will require continued focus on interagency collaboration, new funding sources, and prioritizing funding for such projects in the future (see New ER Recommendation “A” and Appendix E, PM 4.14).

Numerous economic and financial trade-offs are involved in Delta ecosystem protection, restoration, and enhancement projects. State and local decision-making also should consider and recognize the social and economic value a functioning ecosystem would provide to the Delta, its residents, and the state as a whole. To this end, certifications of consistency for covered actions that include environmental protection, restoration, or enhancement—including implementation of recovery plans and mitigation projects—must also describe the cultural, recreational, agricultural, and natural resource benefits expected to result from the action.

Successful ecological restoration in the Delta must also include a well-coordinated and collaborative approach with Delta residents, agricultural interests, airports, and other stakeholders. Protection, restoration, and enhancement projects should consider the surrounding land-use context, and integrate it with the surrounding environment. For example, additional avoidance and mitigation measures may be warranted for wildlife hazards resulting from restoration near airports. Project proponents should use the California Department of Water Resources (DWR) Good Neighbor Checklist when planning and designing restoration projects in order to demonstrate that projects avoid or reduce conflicts with existing uses (see New ER Recommendation “B”).

Functional Floodplains

Restoring ecological processes is both challenging and complex. Environmental planning and implementation actions undertaken to meet different policy objectives, funding requirements, and statutory and regulatory obligations often result in missed restoration opportunities. For example, agencies charged with improving levees to protect Delta communities must meet stringent standards, at high cost, and with tight timelines. These agencies are primarily charged with providing flood protection and, therefore, have an incentive to maintain, repair and rehabilitate levees in-place and to mitigate vegetation removal off-site. Such an approach streamlines permitting requirements and keeps costs low and assessments affordable. Unfortunately, along most of the Sacramento and San Joaquin Rivers, levees are near the water’s edge, leaving little room for habitat features, which often are provided only by trees growing immediately adjacent to or on the levees themselves.

Floodplains provide important opportunities to restore ecosystem processes in the Delta. Projects that expand floodplains at a sufficient scale have the potential to feature all five restoration priority attributes. Natural floodplain processes of erosion, bank cutting, and sediment deposition could be restored. Setting back or removing levees within the floodway would provide lateral connectivity for aquatic and riparian species to access shaded riverine habitat, and would increase important floodplain rearing habitat for juvenile salmon. As described in Core Strategy 1, native fish do particularly well when flows through expanded floodplains follow more natural patterns (Davenport et al. 2016). Floodplain restoration must work in tandem with management of flow patterns in order to create accessible floodplain habitat and support primary production that is available to aquatic organisms.

YOLO BYPASS AND COSUMNES RIVER FLOODPLAINS

The Yolo Bypass and Cosumnes River floodplains offer good illustrations of ecosystem and flood risk-reduction projects working together. These areas provide migratory and rearing habitat for salmon, and important habitat for other native fish, birds, and bats. The California Department of Fish and Wildlife manages the Vic Fazio Yolo Wildlife Area, a 16,000-acre public-private restoration project in the Yolo Bypass, to promote waterfowl and other bird populations. The Cosumnes River Preserve consists of over 50,000 acres jointly owned and operated by the Bureau of Land Management, California Department of Fish and Wildlife, California Department of Water Resources, California State Lands Commission, Sacramento County Regional Parks, The Nature Conservancy, and Ducks Unlimited.

There are limited locations in the Delta where land use, land elevation, and primary fish migration corridors are conducive to physically expand floodplains (see Appendix Q1 for methods). To ensure that these opportunities are not foreclosed, new flood control works and capital improvement projects to existing flood control works in these priority locations (Figure 4-4, which is also Appendix 8A) must evaluate the feasibility (as defined in 23 CCR section 5001[p]) of setting back or removing existing levees in order to physically expand the width of the channel (see ER P4). By engaging in this evaluation early in project planning, before funding decisions are made, reclamation districts and flood control agencies can build partnerships and projects that both reduce flood risk and restore ecosystem function.

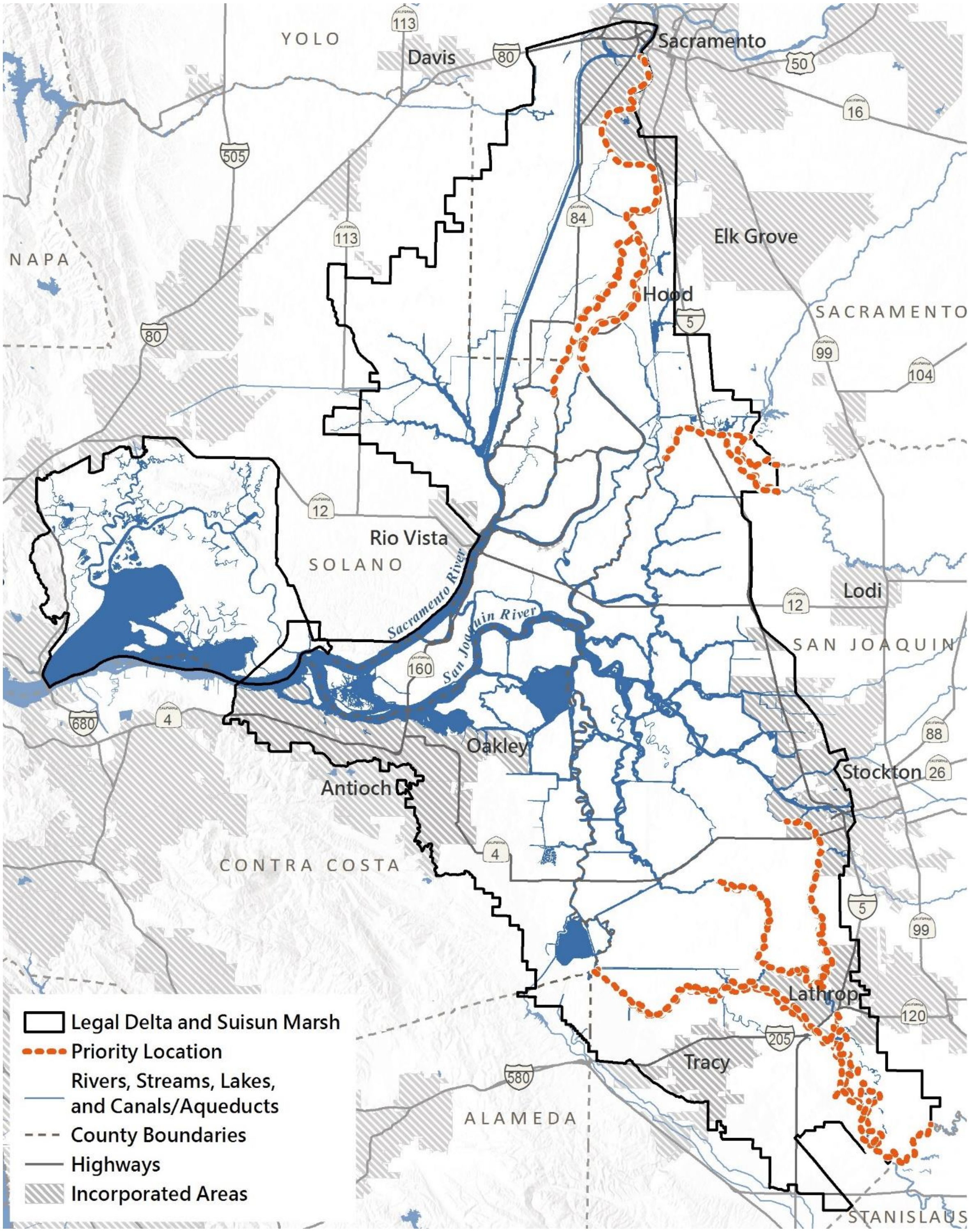

Figure 4-4. Priority Locations to Evaluate Physical Expansion of Floodplains

Figure 4-4. Priority Locations to Evaluate Physical Expansion of Floodplains (contd.)

Figure 4-4 is a map that identifies the Priority Locations to Evaluate Physical Expansion of Floodplains within the Delta, corresponding to the requirements of Ecosystem Restoration Policy 4 (ER P4).

The priority areas are:

- the Sacramento River between the Deepwater Ship Channel and Steamboat Slough, including urban levees in West Sacramento and Sacramento;
- Elk Slough;
- Sutter Slough, from Miner Slough to Elk Slough;
- the Cosumnes River and the Mokelumne River, from the boundary of the Delta to the confluence with Snodgrass Slough;
- the San Joaquin River from the Stanislaus River confluence to Rough and Ready Island, including urban levees in Stockton and levees that run through Lathrop;
- the portion of the Stanislaus River that is within the boundary of the Delta;
- Middle River, from the Old River confluence to the midpoint between Howard Road and Tracy Boulevard;
- Old River, from the San Joaquin River confluence to Hammer Island, including levees that run through Lathrop; and
- Paradise Cut.

This map is also Appendix 8A. Alternative formats of this map are available upon request.

The opportunity to restore ecological processes may be physically constrained in many levee locations. However, thoughtful planning can enable levee projects in these areas to provide other restoration priority attributes, such as improved habitat complexity that supports native species (Davenport et al. 2016). To that end, new flood control works and capital improvements to existing flood control works must evaluate the feasibility of alternatives to increase levee waterside habitat (see ER P4). Waterside habitat could include riparian vegetation, large woody debris, or complexity of bank materials and configurations.

Other state agencies have an active role in ensuring no net loss of riparian and aquatic habitat on levees. The California Department of Fish and Wildlife (CDFW) is charged with ensuring that flood control plans in the Delta provide a net long-term habitat improvement and have a net benefit for aquatic species (California Water Code section 12314). DWR has made significant progress in developing a long-term habitat management program to implement this objective. Through this program, DWR contracts with resource conservation districts (RCD) and other Delta land management entities to maintain riparian habitat enhancement and mitigation sites associated with its special projects and subventions program expenditures.

Transitioning ecosystem restoration efforts toward a more complete ecosystem-based approach is expected to result in improved function and connectivity of restored floodplain, riparian, and tidal wetland habitat throughout the Delta. By 2050, the Delta Plan envisions restoration of more than 30,000 acres of new tidal wetland, more than 13,000 acres of new oak woodland and other upland ecosystems, and nearly 20,000 acres of upland and lowland river floodplain habitat. Restoration of more than 16,000 acres of willow and riparian vegetation communities is envisioned within or adjacent to the restored floodplain habitat. Thus, the Delta Plan envisions a total of approximately 60,000 to 80,000 acres of restored habitat by 2050 (see Appendix E, PM 4.16). These restored habitat patches will be functionally connected for the native species that depend on them, and well-integrated with surrounding land uses. Areas that are physically capable of supporting flood flows will be inundated on a periodic basis (see Appendix E, PM 4.15). Ecosystem protection, restoration, and enhancement projects will provide recreational opportunities, and will support the cultural and natural resource values of Delta communities.

Core Strategy 3: Protect Land for Restoration and Safeguard Against Land Loss

Land reclamation has claimed more than 90 percent of wetlands in the Delta since the mid-1800s (SFEI-ASC 2014). Reclamation has also caused more than 2.5 billion cubic meters of soil loss, at an estimated rate that is 30-times the historical rate at which organic soils formed (Mount and Twiss 2005). Much of the land that once supported intertidal wetlands is now subsided deeply below intertidal elevations. Draining organic soils causes oxidation of organic matter and soil compaction, resulting in carbon gas emissions and land subsidence. Loss of land elevation due to subsidence is ongoing, and in some portions of the Delta, more than an inch of land elevation may be lost per year. Some portions of the central Delta now lie more than 25 feet below sea level. In general, the further land lies below sea level, the less feasible it is to reestablish intertidal habitat, and the greater the risk of permanent inundation and land loss.

Climate change will exacerbate this problem. The California Ocean Protection Council recommends preparing for 0.6 to 2.7 feet of sea level rise at the Golden Gate Bridge by 2050, and from 2.4 to 10.2 feet by 2100 (OPC 2018). Sea level rise from the Ocean Protection Council will be updated every five years based on the best available science. Regardless of whether sea levels rise to the lower end of current projections or the higher end, lands that are currently at intertidal elevations are at risk of sinking too far below the tidal range to support restoration of tidal wetland habitat due to ongoing subsidence. Sea level rise will add pressure on Delta levees, further increasing the risk to people, property, and managed habitats located on subsided islands (Deverel et al. 2016).

Infrastructure and urban development limit the natural ability of wetland vegetation and wetland-dependent species to migrate upland as tides rise (Orr and Sheehan 2012, Dettinger et al. 2016). Tidal wetland habitat that cannot migrate upland and cannot accrete soil matter at a rate fast enough to keep pace with sea level rise will, over time, be lost (Tsao et al. 2015). Urbanization also constrains opportunities to reconfigure and reconnect floodplains to their stream channels. The extent of urban land use in the Delta increased by nearly 50 percent between 1990 and 2014, and it continues to expand. Chapter 5 of the Delta Plan includes a regulatory policy requiring new commercial, residential, and industrial development in the Delta to be located wisely (see Delta as Place Policy [DP P1]); however, land conversion for agriculture-related uses—including the expansion and development of processing facilities, retail establishments, and mining—poses ongoing challenges.

Land conversion, subsidence, and sea level rise pose threats to the Delta ecosystem, especially in the western, central, and southern Delta where subsidence rates are highest. Urgent action is needed to protect land for restoration and safeguard against further land loss.

Protect Land for Restoration

The Delta Reform Act requires that the Delta Plan include subgoals and strategies for restoring large areas of interconnected habitats within the Delta and its watershed (Water Code section 85302[e][1]). In order to accomplish restoration at this scale, there must be sufficient land available to restore. Restoration opportunities in the Delta are constrained by land elevation, which determines the potential to reestablish land-water connections that create and sustain tidal wetland, wetland, and floodplain habitat. In the modern Delta, only a limited amount of land remains at elevations physically capable of supporting intertidal restoration. The best way to safeguard lands currently at intertidal elevations is to reconnect those lands to regular inundation of water that may support the buildup of land through sediment and soil deposits. Tidal wetlands in the Delta naturally accumulate sediment and produce organic material. This allows them to either maintain or raise the land elevation (Drexler et al. 2009).

The locations and extent of tidal wetland in the Delta will inevitably shift with sea level rise. Tidal wetland vegetation can adapt to rising sea levels by either building up a wetland’s base elevation with soil, or by migrating onto adjacent uplands. Restoring natural geomorphic processes, along with more natural functional flows, should increase the potential for intertidal areas in the Delta to keep pace with anticipated levels of sea level rise (Swanson et al. 2015, Schile et al. 2014). In Suisun Marsh, organic material accumulates more slowly, so elevation gain relies more on sediment inputs to wetlands. Because infrastructure separates streams from their basins throughout the Sacramento-San Joaquin River watersheds, sediment loads are lower than the historical rates. This means that in Suisun Marsh, simply reconnecting tidal wetlands may not be enough to adapt to sea level rise (Callaway et al. 2012, Schile et al. 2014). For these reasons, proponents of projects that include tidal wetland protection, restoration, and enhancement in the Delta—and especially in the Suisun Marsh—should design and protect space in upland areas sufficient to allow tidal wetland to migrate onto adjacent uplands under anticipated levels of sea level rise.

SEA LEVEL RISE ADAPTATION PLANNING

Senate Bill (SB) 379, approved in 2015, requires local governments to include the following in their general plans: a climate change vulnerability assessment, measures to address vulnerabilities, and comprehensive hazard mitigation and emergency response strategy in the safety element of their general plans (Gov. Code section 65302[g][4]). For coastal and estuarine jurisdictions, this means planning for sea level rise.

The California Office of Emergency Services publishes the California Adaptation Planning Guide to assist local jurisdictions in addressing the unavoidable consequences of climate change. Potential strategies for adapting to sea level rise include preserving undeveloped land, sealing and protecting existing infrastructure, and strategic retreat of roadways and development from areas expected to be impacted by sea level rise (p. 38).

The California Governor's Office of Planning and Research publishes general plan guidelines, which provide local governments with guidance on SB 379, among other requirements. The guidelines direct local jurisdictions to use the process in the California Adaptation Planning Guide, and as reflected in referenced tools such as Cal-Adapt, to assess the climate change vulnerabilities of their community and to identify feasible methods to avoid or minimize climate change impacts associated with new uses of land.

In parts of the Delta that are currently less than 8 feet below low tide, and parts of the Suisun Marsh that are less than 4.5 feet below low tide, subsidence reversal followed by tidal reconnection would restore ecosystem function. Managed wetlands in the Delta have shown capacity to reverse subsidence at a rate of 1.6 inches (4 centimeters) per year (Miller et al. 2008). Managed wetlands in Suisun Marsh tend to accumulate organic material and gain elevation more slowly because saline conditions slow organic growth. Nonetheless, Suisun Marsh offers important opportunities to raise land elevations through subsidence reversal. Unlike the deeply subsided Delta, much of the Suisun Marsh is still at elevations suitable for restoration of intertidal habitat, including tidal wetland and shallow water habitat. This area provides the brackish portion of the estuary with the potential to support a productive and complex food web, and with space to adapt to sea level rise.

As described in Chapter 5 of the Delta Plan, much of the land in the Delta has subsided to elevations that are too far below sea level to restore its original ecological functions as tidal wetland channels and plains without considerable cost. Providing terrestrial and wetland habitat for native species on deeply subsided Delta lands is expensive and requires intensive, ongoing management. Such lands offer few opportunities to recover native ecosystem forms and functions. However, these lands do provide opportunities for other types of multi-benefit projects (see Appendix Q3 for project opportunities). Deeply subsided islands are appropriate locations for managed wetlands for waterfowl and for wildlife-friendly agriculture (Elphick 2000, Shackelford et al. 2017). Actions at these locations that halt soil oxidation, prevent soil-based carbon emissions, reverse subsidence, and improve migratory bird habitat are especially valuable (Deverel et al. 2016).

The Delta Plan's approach to restoring Delta ecosystem functions is to implement restoration projects in the right places at the right elevations. It is important that investments to improve the Delta ecosystem consider the long-term flood risk associated with the landscape, and where possible, to reduce that risk by reversing or halting subsidence. State and local agencies funding, approving, or building ecosystem protection, restoration, or enhancement actions in the Delta—including recovery and mitigation actions—must ensure the durability of their investments by demonstrating that they are at appropriate elevations, in the context of ongoing subsidence and projected sea level rise (see ER P2 and Figure 4-5). Investments in tidal wetland protection, restoration, and enhancement should focus on areas that are, or will be, exposed to tidal action. Such actions must be designed to accommodate future sea level rise and marsh migration (see ER P2[b]). Ecosystem protection, restoration, and enhancement investments on subsided islands should be made with caution and awareness of the risk of future inundation. Actions at these locations must be designed to safeguard against levee failure over the design life of the project (see ER P2[c]).

Figure 4-6 illustrates the appropriate elevations for the protection, restoration, and enhancement of different classes of natural communities, as well as other activities that support native species recovery and the recovery of critical ecosystem processes. Subsidence reversal for the purpose of reestablishing tidal processes is only appropriate in the shallow subtidal elevation band. Subsidence reversal may be appropriate in more deeply subsided areas when implemented to achieve other project objectives, such as avoiding carbon emissions. Wildlife-friendly agriculture is most appropriate within the deeply subsided islands. The full range of these activities, in appropriate locations, are necessary to support the vision of a restored Delta ecosystem. (Additional discussion of the best available science concerning land subsidence, future sea level rise, and appropriate locations for protection, restoration, and enhancement actions is provided in Appendix Q2.)

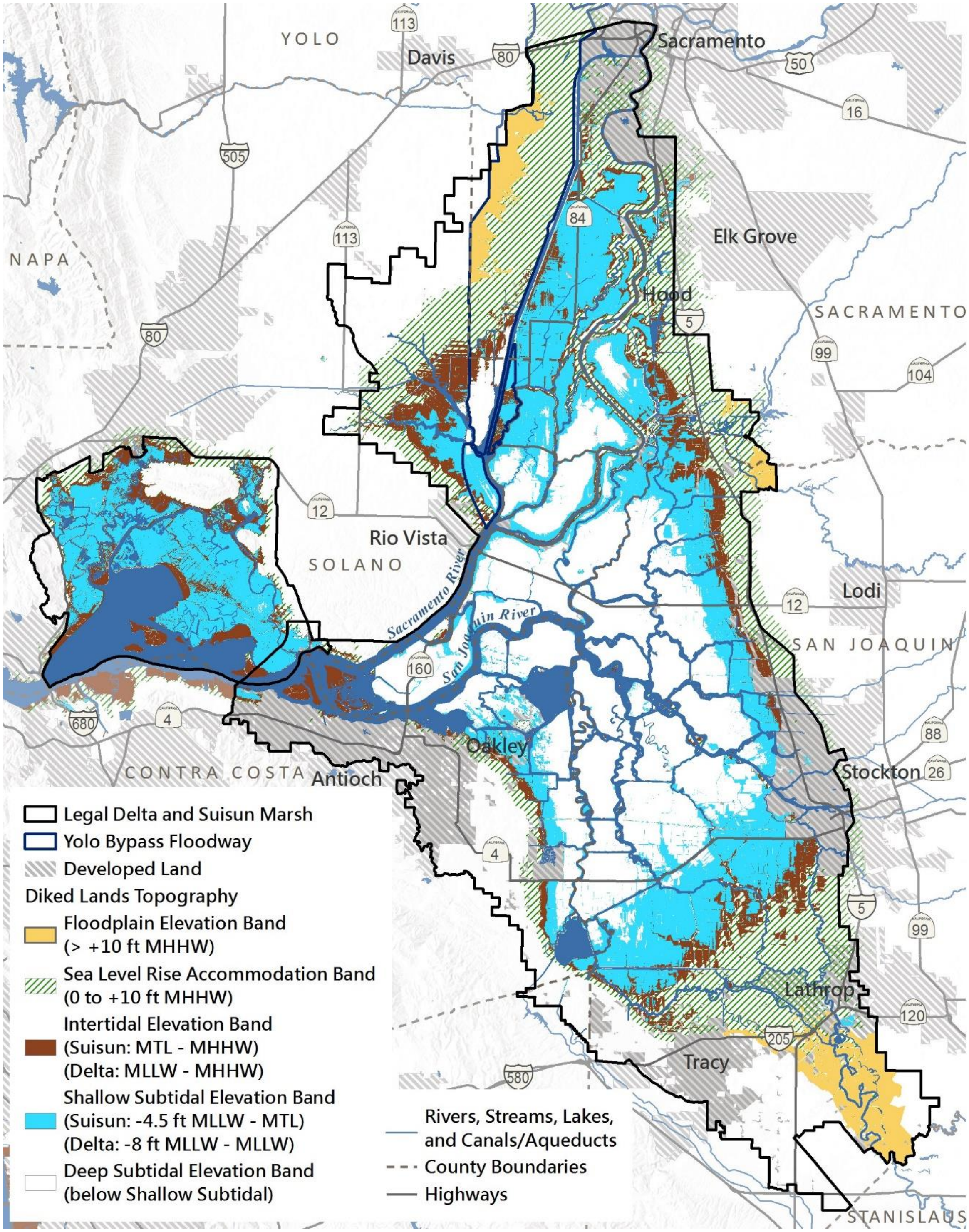

Figure 4-5. Elevation Bands for the Protection, Restoration, and Enhancement of Different Classes of Natural Communities

Figure 4-5. Elevation Bands for the Protection, Restoration, and Enhancement of Different Classes of Natural Communities (contd.)

Figure 4-5 is a map that illustrates Elevation Bands within the Delta. Elevation Bands depicted are:

- The Floodplain Elevation Band, which consists of land at elevations that are greater than or equal to 10 feet mean higher high water. The Floodplain Elevation Band is the least extensive among those shown in the map. Land areas within the Floodplain Elevation Band are concentrated as follows: on the western side of the Yolo Bypass; two small areas west of the City of Galt along the Cosumnes and Mokelumne Rivers; and a conical shaped area at the southeastern tip of the Delta, along the San Joaquin River, south of the City of Lathrop.
- The Sea Level Rise Accommodation Band, which consists of land at elevations that are between 0 to 10 feet mean higher high water. The Sea Level Rise Accommodation Band includes: a narrow strip of land at the northern boundary of Suisun Marsh, small patches of land at the eastern edge of Suisun Marsh; a wide swath of land at the western edge of Cache Slough that continues into much of Yolo Bypass; waterside levee area along the Sacramento River and adjacent channels and sloughs; a strip of land at the eastern boundary of the Delta along Highway 5, between Stockton and Sacramento; a wide swath of land north of Tracy and Lathrop at the base of the San Joaquin River floodplain; and a narrow strip of land extending from Tracy west to Clifton Court Forebay, and northwest to Oakley.
- The Intertidal Elevation Band, which consists of land at elevations between mean tide level and mean higher high water in Suisun Marsh, and between mean lower low water and mean higher high water in the Delta. Existing tidal wetlands in Suisun Marsh and western Delta islands near Pittsburg are located in the Intertidal Elevation Band. Other concentrated land areas located within the Intertidal Elevation Band are within Cache Slough and in the south Delta. There are narrow strips of land located in the Intertidal Elevation Band at the edges of the Sea Level Rise Accommodation Band, extending along Highway 5 between Stockton and Sacramento, and from Tracy to Oakley. Scattered patches of land in the Intertidal Elevation Band are also present on Decker Island, Prospect Island, Merritt Island, Pearson District, McCormack Williamson Tract, and New Hope Tract.
- The Shallow Subtidal Elevation Band, which consists of land at elevations between 4.5 feet below mean lower low water and mean tide in Suisun Marsh, and between 8 feet below mean lower low water and mean lower low water in the Delta. The Shallow Subtidal Elevation Band consists of: the majority of Suisun Marsh; the southeastern corner of Cache Slough; land between the Sacramento River Deep Water Ship Channel and the Sacramento River in the north Delta; the majority of the Pearson District; a strip of land along the eastern edge of the Delta, adjacent to and west of the Intertidal Elevation Band; land south of Highway 4 and adjacent to the Intertidal Elevation Band, in the south Delta; and a narrow strip of land running north from Clifton Court Forebay to Oakley.
- The Deep Subtidal Elevation Band consists of land at elevations that are below the Shallow Subtidal Elevation Band. The Deep Subtidal Elevation Band consists primarily of land areas on islands in the central and western Delta, from Sherman Island in the west to Rindge Tract in the east, and from Victoria Island in the south to Liberty and Grand Islands in the north.

The methods used to develop this map are documented in Appendix Q1. The elevation bands illustrated in this map are the same as the elevation bands identified in Appendix Q2, which discusses the best available science concerning land subsidence, future sea level rise, and appropriate locations for protection, restoration, and enhancement actions.

Alternative formats of this map are available upon request.

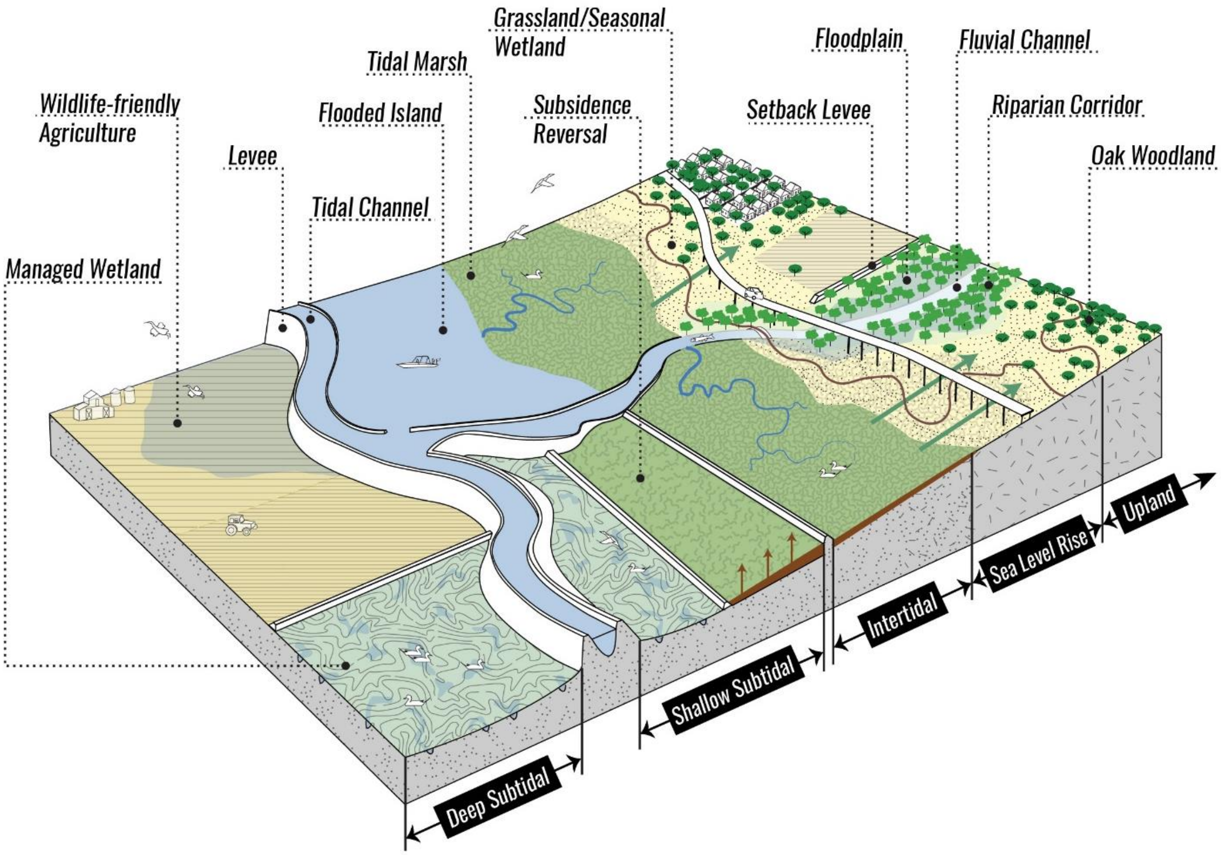

Figure 4-6. Section Diagram of Protected, Restored, and Enhanced Ecosystems at Appropriate Elevations, Including Subsidence Reversal and Wildlife-Friendly Agriculture

Figure 4-6 is a cross-section diagram that illustrates the ecosystem types that occur, and the various ecosystem protection, restoration, and enhancement activities that are appropriate, on the top plane of the diagram, within different Elevation Bands in the Delta on the bottom cross-plane of the diagram. The ecosystem types and appropriate ecosystem protection, restoration, and protection activities are shown on the top plane, corresponding with the elevation band bottom cross-plane as follows: Managed wetlands and wildlife-friendly agriculture are shown at Deep Subtidal elevations. Subsidence reversal is shown at Shallow Subtidal elevations. Tidal wetlands and seasonal wetlands are shown at Intertidal elevations. A setback levee is shown in the Floodplain Elevation Band protecting upland urban development from the fluvial channel, such that the riparian corridor is connected to its floodplain. Projected sea level rise is shown in the Sea Level Rise Elevation Band between the intertidal and upland ecosystems. The roadway in the diagram is elevated above the projected sea level rise elevation, to exemplify adaptation and resilience.

This figure demonstrates how ecosystem protection, enhancement, and restoration activities can be integrated into, and supportive of, the surrounding agricultural context of the Delta.

Source: SFEI 2019

State and local agencies must also protect the few remaining areas in the Delta and Suisun Marsh that present opportunities to reestablish land-water connections. The less-subsided flood basins, river corridors, and reclaimed wetlands on the Delta's perimeter offer the most promising restoration opportunities. Accordingly, the Delta Plan identifies six Priority Habitat Restoration Areas (Figure 4-7):

- **Yolo Bypass, from the Fremont Weir south toward the Delta.** Winter and spring flooding of the Yolo Bypass provides substantial benefits for spawning and rearing of Sacramento splittail and rearing of salmon (Sommer et al. 2001, Moyle et al. 2007). Restoration of the Yolo Bypass can create conditions that promote enhanced growth and survival of juvenile spring- and winter-run salmon, among other species, and can benefit other migrating salmon.
- **Cache Slough Complex, southwest of the Yolo Bypass.** The flood basins entering the Cache Slough Complex are located at the interface between river and tidally influenced portions of the Delta. Habitat restoration at Cache Slough can create conditions that help recover delta smelt and that benefit migrating salmon.
- **Cosumnes River-Mokelumne River confluence.** While most of the riparian forests of the Central Valley have long been lost, the Cosumnes River floodplain possesses exceptionally large stands of remnant valley oak riparian forests, as well as an intact flow regime because the Cosumnes River is not regulated by a major dam. Restoring seasonal floodplains and tidal wetlands in this area can benefit migrating salmon and provide food-web support.
- **Lower San Joaquin River floodplain between Stockton and Manteca.** Historically, the south Delta and its connection to the lower San Joaquin River contained a complex network of channels with low natural berms, large woody debris, willows, and other shrubs with upland areas supporting open oak woodlands. Restoring this area to a mix of tidal wetland, riparian habitats, and wildlife-friendly agriculture could create conditions to recover riparian brush rabbits and Swainson's hawks, benefit migrating salmon, and serve to reduce the risks from flooding in urban areas.
- **Suisun Marsh.** The Suisun Marsh is the largest wetland area on the West Coast of the contiguous United States; however, it is mostly managed for waterfowl, with levees that disconnect its wetlands from the estuary. Restoration of tidal wetland and associated habitats here can aid the recovery of longfin smelt, delta smelt, and spring- and winter-run salmon, and support Suisun song sparrows and saltmarsh harvest mice.
- **Western Delta/Eastern Contra Costa County.** Some islands and tracts at appropriate elevations may be desirable sites for restoration of tidal wetland and channel margins to provide food-web support and habitat for native species.

These six Priority Habitat Restoration Areas have been highly altered by almost two centuries of modern-era human use and exposure to multiple stressors. Reestablishing geomorphic processes and habitat for native species in these areas requires a careful assessment of opportunities and challenges that maintains focus on long-term ecological outcomes when making short-term land-use decisions. Covered actions must demonstrate that they would not prevent, impede, or constrain future opportunities to restore habitat in the six Priority Habitat Restoration Areas (see ER P3). Protecting these areas will contribute sufficient land area, at the appropriate elevations and in appropriate locations, to restore critical Delta habitat types and to achieve the vision of a restored Delta ecosystem.

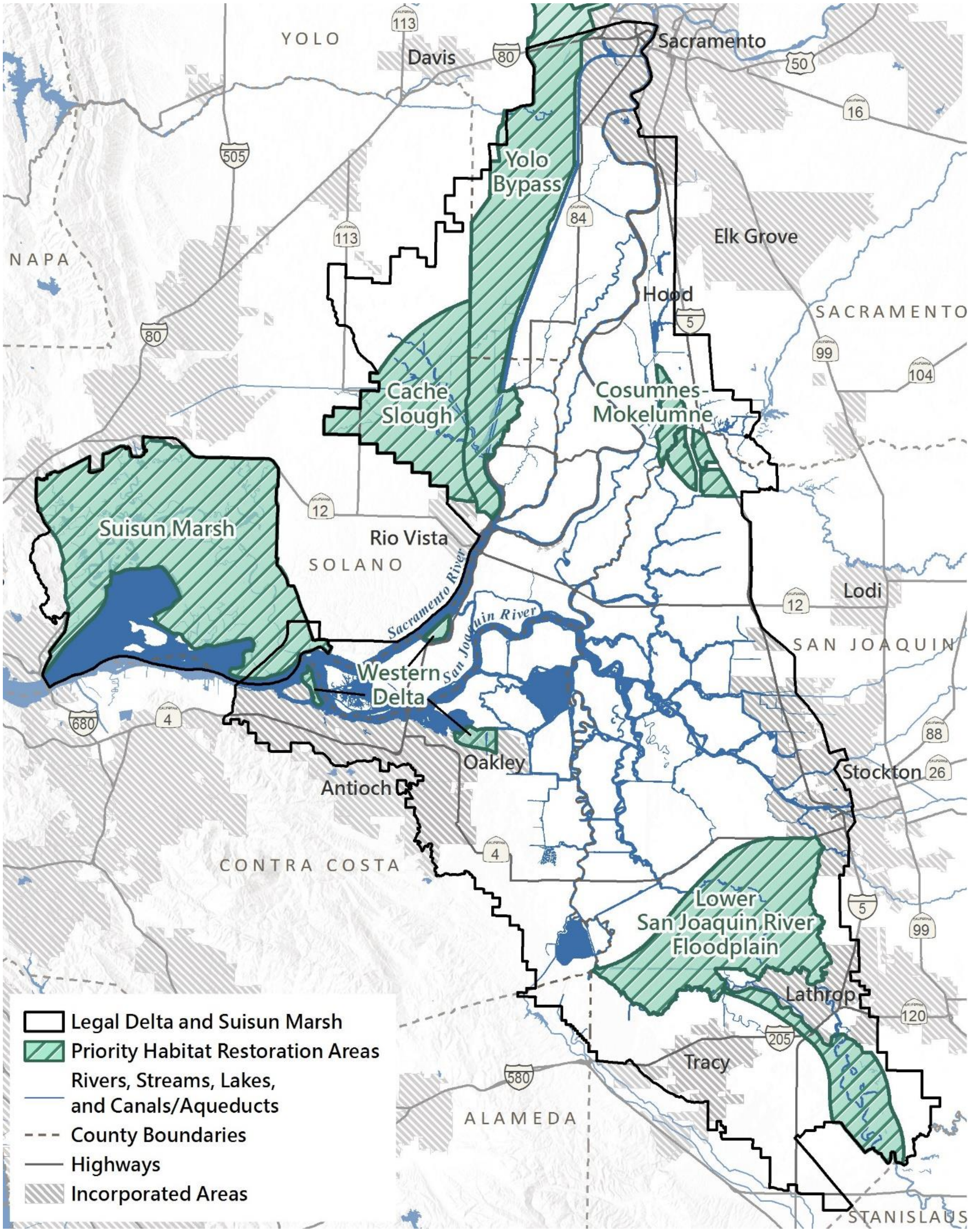

Figure 4-7. Priority Habitat Restoration Areas

The Priority Habitat Restoration Areas are the same as those depicted in Appendix 5.

Figure 4-7. Priority Habitat Restoration Areas (contd.)

Figure 4-7 is a map that delineates Priority Habitat Restoration Areas (PHRA) within the Delta.

Suisun Marsh PHRA is located at the western edge of the Delta, south of Fairfield and Suisun City, and east of Benicia. It encompasses nearly the same area as the Suisun Marsh boundary, except that the PHRA does not extend west beyond Highway 680, nor into the developed portion of Suisun City. The Yolo Bypass PHRA is located in southern Yolo County and eastern Solano County, adjacent to Cache Slough, which is located entirely within eastern Solano County (north of Rio Vista). The Yolo Bypass PHRA encompasses the same area as the Yolo Bypass. The Cache Slough PHRA extends from the boundary of the Delta on the south and west to Yolo Bypass on the east. The Cosumnes/Mokelumne PHRA is located at the western edge of Highway 5 between Elk Grove and Lodi. The Western Delta PHRA consists of three separate areas: Decker Island, Winter Island, and Dutch Slough. The Lower San Joaquin River Floodplain PHRA is located south of Highway 4 between Interstate 5 and 205, including the southwestern portions of Stockton and western side of Lathrop.

Alternative formats of this map are available upon request.

The San Francisco Bay Conservation and Development Commission (BCDC) is responsible for protecting Suisun Marsh (as part of the San Francisco Bay and its shoreline) through the San Francisco Bay Plan, as described in Chapter 5. BCDC provides special protection of the Suisun Marsh under the Suisun Marsh Preservation Act through the Suisun Marsh Protection Plan (SMPP). BCDC is developing regional strategies to address the impacts of sea level rise and climate change on the Bay. BCDC amended the San Francisco Bay Plan in 2011 to address climate change and sea level rise using projections developed by the California Ocean Protection Council (2011). The 2014 Suisun Marsh Habitat Management, Preservation, and Restoration Plan (SMP) developed by the Suisun Marsh Principal Agencies, is a 30-year habitat restoration and enhancement framework that includes sea level rise projections from 2008. The SMPP and the Suisun Marsh Local Protection Program should also be amended to address climate change and rising sea level (ER R5).

Safeguard Against Land Loss

Alongside, but separate from, actions to protect ongoing investments and opportunities for restoration, the current rapid pace of subsidence must be reduced, halted, and reversed. The ongoing loss of land due to subsidence and sea level rise is a critical stressor that threatens the livelihood of those who live and work in the Delta, statewide water supply reliability, and critical habitat for native species. Models accounting for subsidence and sea level rise indicate that between 2009 and 2019, approximately 3,500 acres of diked lands in the Delta and 3,000 acres of diked lands in Suisun Marsh subsided below intertidal elevations and are now at subtidal elevations.

WORKING LANDS PROGRAMS

Supporting biodiversity on working agricultural lands has been a focus of many conservation funding programs within the Central Valley. This approach generally involves modifying the management of agricultural lands to provide ancillary benefits to a particular wildlife species or a group of species with similar habitat needs. For example, flooded rice fields can provide surrogate wetland habitats for species such as the giant garter snake (*Thamnophis gigas*). Many crops and some annually cultivated crops provide important foraging habitat for raptors, including Swainson's hawk (*Buteo swainsoni*), and winter-flooded croplands provide essential foraging and roosting habitat for greater sandhill crane (*Antigone canadensis tabida*) along with other waterfowl and shorebird species (SFEI-ASC 2016, Dybala et al. 2017, Strum et al. 2017).

Partnerships with farmers, to achieve ecological objectives, take advantage of farmers' experience managing large areas of land (e.g., controlling for pests, keeping away trespassers). These partnerships also enable private landowners to maintain ownership of their property, ensuring a stable tax base for local governments and maintaining the agricultural heritage of the Delta.

The same process that causes subsidence also works against the state's carbon neutrality goal, declared in state Executive Order B-55-18. The majority of soil carbon loss in California is attributed to oxidation of organic soils in the Delta (ARB 2018). The Natural and Working Lands Climate Change Implementation Plan was developed to implement this executive order by identifying land-based methods to sequester carbon and setting a target of restoring 2,500-2,800 acres of Delta wetlands per year to stop carbon losses associated with soil oxidation (California Natural Resources Agency et al. 2019). These restoration activities would also have the benefit of helping to stop subsidence and reversing it over time.

Public agencies own more than 35,000 acres of deeply subsided lands in the Delta and Suisun Marsh, and they play a critical role in halting and reversing subsidence. State agencies should not enter into leases that contribute to subsidence on state-owned lands (see Delta as Place Recommendation 7). Rather, state and local agencies should take proactive steps to evaluate the feasibility of subsidence-reversal projects, and update applicable management plans that identify land management goals; identify appropriate public or private uses for that property; and describe the operation and maintenance requirements needed to implement management goals, to incorporate actions that reduce, halt, and reverse subsidence (see New ER Recommendation “E”).

Subsidence reversal activities support multiple, diverse goals, from protecting the state's water supply to reducing flood risk and reducing carbon emissions. Some subsidence reversal approaches, such as managed wetlands and rice cultivation, can also support migratory birds by providing food sources and habitat. In less-subsided portions of the Delta and Suisun Marsh, subsidence reversal could also raise land elevations to mean tide level and create opportunities to reestablish connections to the tidal regime. State agencies should articulate clear objectives when investing in subsidence-reversal projects and should target subsidence-reversal investments to appropriate locations (see New ER Recommendation “C”).

The Sacramento-San Joaquin Delta Conservancy (Delta Conservancy) has been working closely with local agencies, nonprofit organizations, universities, and private landowners to develop pilot projects and to inform policies that halt or reverse subsidence to reduce carbon emissions. This collaboration led to the development of the American Carbon Registry protocol for voluntary carbon offsets for wetland creation and rice cultivation in the Delta. If offsets are approved to be sold in the cap-and-trade compliance market, higher prices for carbon offsets could incentivize participation among private landowners, and more widespread adoption of practices to halt and reverse subsidence in the Delta. The Delta Conservancy and its partners should continue efforts to develop incentive programs that encourage land management practices that halt and reverse subsidence (see New ER Recommendation “C”).

Local agencies and districts, including resource conservation districts (RCD), reclamation districts (RD), water districts, and other Delta land stewardship entities should identify best practices to halt subsidence and support native species on working lands within their respective jurisdictions. RCDs are locally governed special districts of the state that are dedicated to conservation and stewardship of agricultural and natural resources and are therefore well-suited to improve agricultural land management practices in a manner that benefits species and allows for continued agricultural productivity, while avoiding unintended consequences for nearby landowners. Some RDs and water districts are actively engaged in implementing pilot projects to halt or reverse subsidence. State agencies should pursue new funding sources to support these local partners to develop and implement practices that safeguard against land loss and support native species (see New ER Recommendation “D”).

Collaborative efforts of state, local, and private partners can prevent and, in limited cases, reverse subsidence to the extent that habitat can be restored in locations throughout the Delta and Suisun Marsh. Accordingly, the number of carbon sequestration projects and acres of subsidence reversal should accelerate in the next decade. By implementing 3,500 acres of subsidence reversal in the Delta and 3,000 acres in Suisun Marsh, by or before 2030, projected loss of land at elevations suitable for tidal restoration could be reversed (see Appendix E, PM 4.12). Encouraging subsidence-reversal projects in less-subsided areas of the Delta and Suisun Marsh will help to ensure no net loss of intertidal wetland restoration on the landscape through 2100. These projects will also contribute to the broader Delta Plan goal to implement subsidence-reversal projects on 30,000 net new acres in the Delta and Suisun Marsh by 2030 (see Appendix E, PM 5.2).

Core Strategy 4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

Native species evolved in the varied, complex floodplains, wetlands, and other habitats of the historical Delta. Channelizing waterways, altering riparian vegetation structure, stabilizing flow patterns, and impairing water quality have all contributed to conditions that favor nonnative invasive species. Nonnative species now affect virtually all components of the Delta ecosystem. Nonnatives can take over physical space, compete for food and nutrients, alter food webs, modify the physical habitat structure, or prey upon native species (CDFW 2014). Thus, nonnative species are both symptomatic and a cause of widespread ecosystem degradation.

Promoting self-sustaining, diverse populations of native and valued species by reducing risk of take and harm from invasive species is one of the Delta Reform Act's subgoals for restoring a healthy ecosystem (Water Code section 85302[e]). Large-scale ecosystem restoration supports recovery of native species, in part by removing conditions favored by nonnative species. However, there is also a need to ensure the immediate survival of native species populations within the current, degraded conditions of the Delta ecosystem. Specifically, some native fish populations require targeted interventions and active management to sustain and increase their numbers to a threshold at which they are self-sustaining. Major fish management actions include prioritizing and remediating migration barriers, restoring and managing migration corridors, managing hatcheries, and identifying and tracking salmonid fish and other native species.

Prevent Introduction of Nonnative Invasive Species and Manage Nonnative Species Impacts

Nonnative species in the Delta fall broadly into the following four categories:

1) **Naturalized Species:** These nonnative species were intentionally introduced to the Delta, often to provide some economic benefit (e.g., striped bass recreational fishery), and now have established self-sustaining populations.
2) **Widespread and Unmanaged Species:** These nonnative species are widespread and known to cause problems (e.g., invasive Asian clams that rapidly deplete plankton from the water column), but they are not currently being actively managed-typically because of lack of feasible control options.
3) **Widespread and Managed Species:** These species are known to be major challenges and significant investments are being made to keep their abundance and distribution in check (e.g., water hyacinth, giant reed). Given how widespread and well-established these species are in the Delta ecosystem, the focus of management for these species is to control their abundance rather than to fully eradicate them from the Delta.
4) **Emerging Species of Concern**: These nonnative species have been recently found (e.g., nutria) or have a high potential to invade the Delta in the near future (e.g., quagga mussels), and their presence poses a major threat to the Delta ecosystem and/or human infrastructure. If already in the Delta, they are the focus of eradication efforts, and if not already in the Delta, they are the focus of invasive species prevention efforts.

Some nonnative species are also invasive. Invasive species are nonnative species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. A variety of nonnative invasive species are prevalent within the Delta. Nonnative invasive aquatic weeds in the Delta include water hyacinth, Brazilian waterweed, water pennywort, Eurasian water milfoil, and parrot feather. These weeds flourish across wide areas where they act as powerful “ecosystem engineers” by altering ecosystems, sometimes creating dense mats or thickets that displace native plants, reduce food-web support, reduce turbidity, interfere with water conveyance and flood control facilities, and hinder boating (Jones et al. 1994, Breitburg et al. 2010). Nonnative invasive aquatic vegetation also provides favorable habitat conditions for nonnative invasive predatory fish species, including largemouth bass (Ferrari et al. 2014, Conrad et al. 2016).

Nonnative invasive invertebrate species also profoundly affect the aquatic food web in the Delta. Nonnative invasive overbite clams contribute to the reduction of algae and some invertebrates in the Delta, especially in Suisun Bay (Kimmerer 2006). This represents a loss at the base of the food web, contributing to the decline of delta smelt and other open-water fish (Sommer et al. 2007). Proliferation of the overbite clam in shallow sediments contributes to biomagnification of contaminants, such as selenium, throughout the pelagic food web (U.S. Fish and Wildlife Service 2008, Thompson and Parchaso 2012). The introduced Asian clam is abundant in freshwater parts of the Delta and in the mainstems of the Sacramento and San Joaquin Rivers. This species can alter channel bottoms and competes with native freshwater mussels for food and space (Claudi and Leach 2000). In addition, introduced zooplankton, which are linked to a decrease in nutritional value for fish, have almost completely replaced native zooplankton (Winder and Jassby 2011).

Future invasions by new nonnative species, like zebra and quagga mussels, are likely. Neither has been observed in the Delta yet, but they have proven to be highly invasive and can colonize in high densities that affect water flow and quality through canals and pipes. Once introduced, nonnative invasive species are difficult and expensive to control, and often impossible to eradicate. Therefore, preventing introduction of new nonnative species is a priority.

Aquatic invertebrates mainly enter the estuary in the ballast water of ships and on their hulls. California requires vessels arriving from outside the United States Exclusive Economic Zone to manage ballast water either through retention, mid-ocean exchange, or discharge to a shore-based treatment facility. The California State Lands Commission (CSLC) sets limits for allowable concentrations of living organisms in discharged ballast water. In 2018, the Council completed an independent scientific review for the CSLC, evaluating the feasibility of shore-based ballast water reception and treatment in California. A shore-based barge solution was determined to be the most cost-effective option to reduce the potential for conflicts with land-use restrictions and permitting requirements.

MANAGING INVASIVE SPECIES IN THE DELTA

Several federal and state agency programs detect and manage invasive species in the Delta, often in collaboration with nonprofit organizations, universities, and other stakeholders.

- The Sacramento-San Joaquin Delta Conservancy has organized a Delta Interagency Invasive Species Coordination Team to foster communication and collaboration among agencies that detect, prevent, and manage invasive species and to restore invaded habitats in the Delta. The team includes participants from six state agencies, three federal agencies, and the University of California, Davis.
- The California Invasive Plant Council (Cal-IPC), a nonprofit organization, produces an inventory of invasive plants present in California. The Cal-IPC list guides planning processes by identifying which invasive plants are more likely to be threats.
- The California Department of Food and Agriculture is the lead agency for the control of noxious terrestrial weeds in California.
- The California Department of Parks and Recreation, Division of Boating and Waterways is the lead agency for the control of noxious aquatic weeds in the Delta.
- The Delta Region Areawide Aquatic Weed Project is a group comprised of university researchers, public agencies, and resource managers that help management agencies optimize long-term sustainable control methods for various aquatic weeds, including water hyacinth and giant reed. The group supports research by the U.S. Department and Agriculture and University of California, Davis scientists to test new herbicides and integrated control methods.

The Delta Plan encourages an increased focus on nonnative invasive species in the Delta and Suisun Marsh and continued collaboration among agencies to address and manage such species (see ER R7). To protect the Delta ecosystem, covered actions that have a reasonable probability of introducing new nonnative invasive species, or improving habitat conditions for nonnative invasive species, must fully consider and avoid or mitigate such potential (see ER P5). To measure progress, the Delta Plan tracks the establishment of new nonnative invasive species of fish, plants, and invertebrates; and the large-scale treatment and reduction of nonnative invasive plant species. By 2030, these actions are expected to reduce the land area covered by nonnative invasive plant species by half (see Appendix E, PM 4.10).

NUTRIA: AN EMERGING THREAT IN THE DELTA

The discovery that nutria, an invasive species of rodent, have reestablished in California has sparked immediate alarm, because nutria infestations in other portions of the country have resulted in widespread destruction of emergent wetland habitat. Failing to address the nutria threat may result not only in devastating impacts to the limited and fragile remaining wetlands in the Delta and the state but also increased flood risk to farms, houses, and infrastructure as nutria burrowing habits undermine levees. In response to the nutria threat, the interagency Nutria Response Team was convened and includes representatives from California Department of Fish and Wildlife, California Department of Food and Agriculture, California Department of Parks and Recreation, Department of Water Resources, U.S. Department of Agriculture, U.S. Fish and Wildlife Service, and county agricultural commissioner offices. This team is in the process of developing an eradication plan, which will include determining the full extent of the nutria infestation in California.

Improve Fish Management

The Delta serves as a migration corridor for all anadromous fish species in the Central Valley as they return to their natal rivers to spawn, and during juvenile outmigration downstream to the ocean. The Delta Reform Act requires that the Delta Plan include measures to promote functional corridors for migratory species and conditions conducive to doubling salmon populations (Water Code section 85302[c]). The Delta Plan's primary mechanism for achieving these goals is restoring ecosystem function, as described in Core Strategy 2. However, some endemic and migratory fish populations are so threatened that they require active management in order to sustain current population levels until large-scale ecosystem function is restored.

A major obstacle affecting the function of streams and rivers for fish migration is instream, man-made structures (DWR 2014). Barriers to migration can negatively affect survival of anadromous fish by limiting access to refuge habitat, spawning and rearing grounds, and contributing to stressors that adversely affect overall species survival (NMFS 2009, 2014).

The most formidable barriers are located upstream on the Sacramento and San Joaquin Rivers and their tributaries, especially the many large and small dams associated with reservoirs, including Shasta, Folsom, and Millerton Lakes and Lake Oroville. Other physical barriers in the Delta that disrupt fish migration include structures with ledges and drops, such as weirs; man-made structures, including bridge pilings, boat docks, narrow channels with riprapped edges; or the intakes of the SWP and CVP pumps, which entrain out-migrating juvenile salmonids and create attractive spots for predatory fish to feed on migrating species.

In the Central Valley, less than one-fifth of the historical spawning habitat is still accessible to Chinook salmon and steelhead (Reynolds et al. 1993, Yoshiyama et al. 2001). Juvenile salmon (or smolts) leaving the Sacramento River and entering the interior Delta through the Delta Cross Channel or Georgiana Slough have significantly lower survival rates than fish that stay in the Sacramento River (Newman 2008, Perry et al. 2015). There are around 3,000 unscreened water diversions operating throughout the entire Delta watershed, almost all of which are small agricultural intake pipes. The overwhelming majority of the larger intakes in the Delta watershed have been screened as part of initiatives undertaken in recent decades to reduce entrainment loss of native juvenile fish.

Remediating fish passage barriers would enable native Chinook salmon and Central Valley steelhead to access their natural spawning habitat in the upper Delta watershed. Due to limited resources and the large number of known barriers and unscreened diversions in the Delta, priority barriers should be remediated, and additional data should be collected to inform prioritization and remediation of unscreened diversions (see New ER Recommendation “H” and Appendix E, PM 4.13). For the purposes of the Delta Plan, priority barriers are those identified in Appendix K to the Central Valley Flood Protection Plan Conservation Strategy (DWR 2016), lists of priority barriers that CDFW maintains and updates on an annual basis, and all large rim dams in the Delta watershed (see Appendix E, PM 4.13). These include Lisbon Weir in the Delta and several others located within the lower Sacramento River Basin just outside the Delta (e.g., Sacramento Weir, Fremont Weir, Cache Creek Settling Basin Weir, and five Tule Canal agricultural crossings).

State and federal agencies should also fund and implement projects that improve habitat conditions and reduce predation risk for juvenile salmonids along the priority migration corridors identified in Figure 4-8 (see New ER Recommendation “I”). These corridors represent water bodies that juvenile salmon use for rearing and outmigration (CALFED 2005, DWR 2013c). Redundancy adds ecological resilience by establishing route alternatives that may vary in significance from year to year (Council 2018, SFEI-ASC 2016). Expanding floodplains by removing or breaching existing levees, improving waterside habitat, managing nonnative aquatic weeds, and augmenting spawning gravels could improve survival of juvenile salmon, among other strategies (Moyle et al. 2012, SFEI-ASC 2016). Additional novel approaches to migration corridor management should be considered, including the use of behavioral fish guidance structures. For example, a bio-acoustic fish fence was tested at Georgiana Slough and demonstrated promise toward guiding fish away from pathways where survival is decreased (Perry et al. 2014).

Until priority barriers are remediated and critical migration corridors are restored, maintaining populations of anadromous fish requires the use of hatcheries to ensure sufficient reproduction. Hatcheries require careful management to maintain the genetic integrity of the salmonids (Araki et al. 2008, NMFS 2014). Hatchery fish interbreed and compete with wild fish for spawning, rearing, and foraging habitat, which can lead to a long-term decline in genetic diversity within the population (Mount et al. 2012). Recent research evaluating 80 years of hatchery releases in the Central Valley highlights the effect of hatchery release location and other factors on straying rates of hatchery fish and potential impacts on natural stocks (Sturrock et al. 2019).

The California Hatchery Scientific Research Group (2012) recommended a Hatchery and Genetic Management Plan (HGMP) for each California Hatchery Program to ensure the conservation and recovery of listed Evolutionary Significant Units. NMFS requires hatcheries to develop and implement HGMPs; to date only U.S. Fish and Wildlife Service's Livingston Stone National Fish Hatchery has a finalized and approved HGMP for a Central Valley species. Some Central Valley state hatcheries have developed draft HGMPs (Feather River Hatchery and Nimbus Hatchery), but others have either not drafted HGMPs (Merced River Hatchery, Mokelumne River Hatchery) or instead developed an Adaptive Management Plan (Coleman National Fish Hatchery). Hatcheries should continue to develop and implement HGMPs to reduce genetic and fitness risks to natural-origin and listed species (see ER R8).

These migration and reproductive interventions are expected to contribute to increased abundance of native fish species, relative to the abundance of all fish species (see Appendix E, PM 4.10). Over time, these management actions are intended to help to sustain native fish populations until large-scale ecosystem restoration can be implemented, and fish populations become self-sustaining. State agencies and academic researchers should coordinate and use best available science and technology to tag fish within the Delta, identify fish migration pathways, estimate survival, and track progress (see ER R9).

PREDATORY FISH MANAGEMENT

Modification of the Delta ecosystem since the mid-1800s has resulted in system-wide and localized conditions that favor nonnative predatory fish. The current system of highly interconnected and relatively uniform deep channels provides excellent habitat for nonnative predators, and it lacks the heterogeneous shallow tidal habitat that provides foraging habitat and refuge from predation for native fishes (Mount et al. 2012). Additionally, nonnative submersed and floating aquatic vegetation provides favorable habitat conditions for many nonnative predatory fish species (Conrad et al. 2016). Predation hot spots exist in the Delta where predators congregate and consume large numbers of prey that are disoriented by unnatural flow patterns and modified habitat structures, such as water intakes.

Nonnative fish species such as striped bass have been shown to prey on native salmon and smelt. Efforts are underway to evaluate the effectiveness of targeted removal of nonnative fish predators from the Delta for improving native fish survival. Currently, DWR is implementing a robust study to evaluate the effectiveness of various techniques to capture and selectively remove nonnative predatory fish from Clifton Court Forebay, a known predator hot spot. DWR will evaluate whether these predator removal treatments are correlated to improved survival of tagged fish traversing the Forebay. Direct removal of nonnative fish predators alone, though, is unlikely to provide long-term improvements to native fish survival throughout the Delta (Grossman et al. 2016). Other actions such as restoring and enhancing bankside habitat to provide predation refuge and foraging habitat for juvenile salmonids, as well as restoring tidal wetlands and seasonal floodplains, will be crucial components within a range of management actions to reduce the net effect of nonnative fish predators on native fish populations (Moyle et al. 2012).

The Delta Plan includes recommendations in Chapter 3 for DWR, Reclamation, and local beneficiary agencies to evaluate and implement effective predator control actions, such as fishery management and directed removal programs, to minimize predation on juvenile salmon and steelhead in Clifton Court Forebay and in the primary channel at the Tracy Fish Collection Facility.

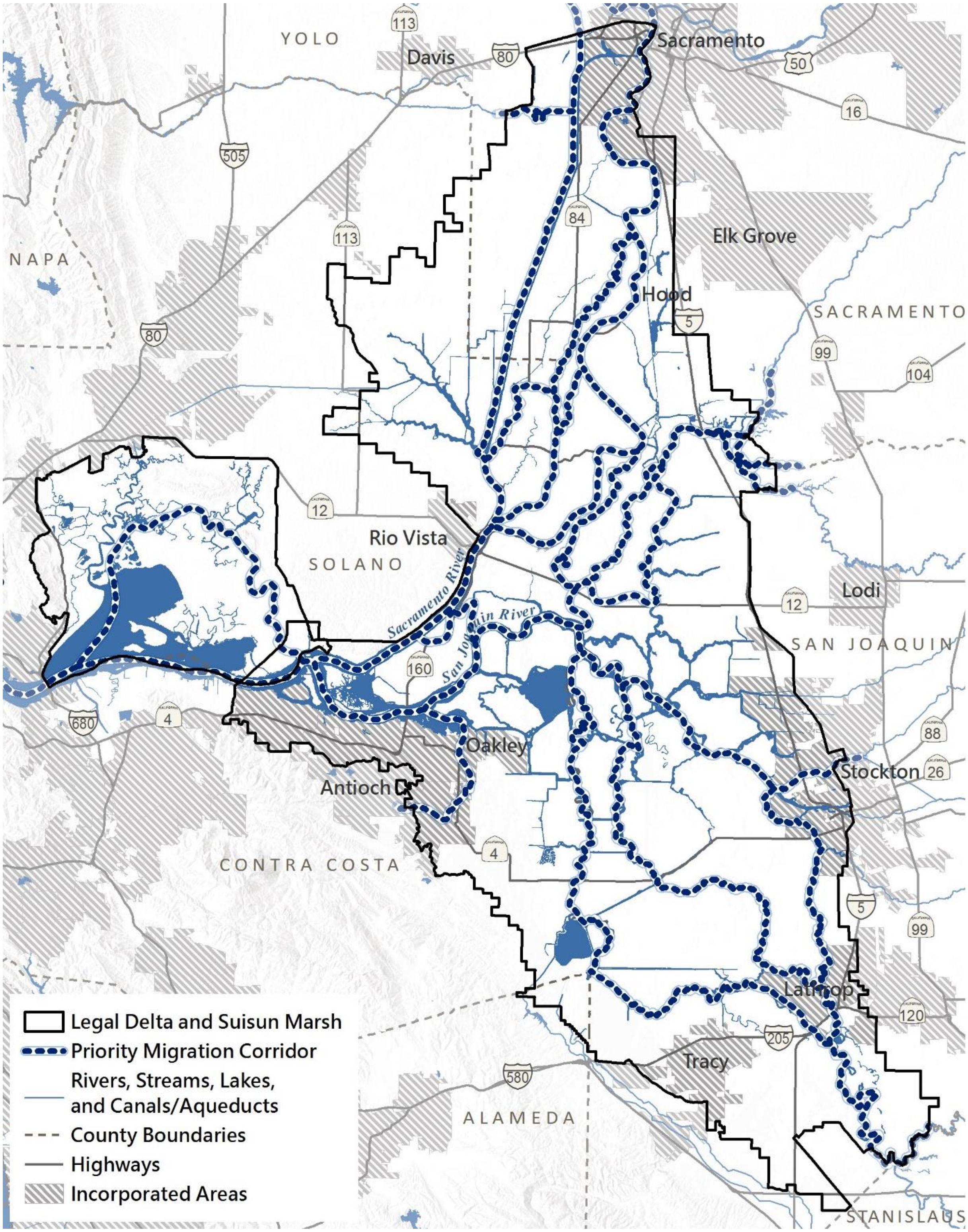

Figure 4-8. Priority Migration Corridors

Figure 4-8. Priority Migration Corridors (contd.)

Figure 4-8 is a map that identifies Priority Migration Corridors for native migratory fish species within the Delta. The Priority Migration Corridors depicted in this map are, starting at the northern end of the Delta and moving clockwise: the Sacramento River Deep Water Ship Channel and toe drain, Sacramento River, Elk Slough, Sutter Slough, Steamboat Slough, Georgiana Slough, the Cosumnes River, North and South Fork of the Mokelumne River, Threemile Slough, the San Joaquin River, Burns Cutoff, Paradise Cut, Middle River, Old River, Marsh Creek, Sand Creek, and Montezuma Slough. Priority Migration Corridors are also depicted running through Grizzly Bay and Suisun Bay within Suisun Marsh, and heading west to Carquinez Strait. These Priority Migration Corridors run through and adjacent to the cities of West Sacramento, Sacramento, Isleton, Stockton, Lathrop, Brentwood, Oakley, and Rio Vista.

Alternative formats of this map are available upon request.

Core Strategy 5: Improve Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement

Many state, local, and federal plans, programs, and projects address ecosystem protection, restoration, and enhancement in the Delta. This includes plans to recover and conserve species, programs to distribute public grants and loans, and single- and multi-benefit projects. However, these plans, programs, and projects typically have different objectives and desired outcomes, depending on individual agency missions, legislative direction, or other guidance. As a result, the combined effect of efforts to protect, restore, and enhance the Delta ecosystem has not been equal to the sum of its parts. A common framework is needed to realize the collective benefits of individual efforts, coordinate and align those efforts, and maximize opportunities to protect, restore, and enhance the Delta ecosystem.

Most restoration in the Delta has traditionally been implemented to meet regulatory requirements under a variety of laws and regulations, including the Federal Endangered Species Act (ESA), the Clean Water Act, the California Fish and Game Code, the California Water Code, and others. These laws and regulations may require restoration to compensate for impacts to species and their habitats. Implementation of these laws and regulations provide important benefits to the Delta ecosystem, and established goals and objectives for habitats and species, including Recovery Plans and Habitat Conservation Plans under ESA (Council 2018a, Appendix Q4). However, additional progress could be made by coordinating planning efforts among the agencies responsible for implementation.

An existing mechanism for coordination between among the agencies responsible for implementation of ecosystem protection, restoration, and enhancement actions and the Council is the early consultation process for covered action certification. State and local agencies may consult with the Council early in the planning process on the consistency of proposed projects with applicable regulatory policies in the Delta Plan. For ecosystem restoration projects, it is critically important that early consultation occur in the earliest possible stages of the California Environmental Quality Act (CEQA) review process to ensure that Delta

Plan requirements are incorporated as features of proposed projects or as mitigation measures.

Recent planning processes, such as the Delta Conservation Framework (Sloop et al. 2018) and the Public Land Strategy (2019), have helped identify a conservation vision for regions throughout the Delta. As these and other similar planning processes continue, there is a need to align state, local, and federal plans and programs that address ecosystem protection, restoration, and enhancement within the Delta and to accelerate implementation (see New ER Recommendation “G”). This includes promoting the priority attributes (described in Core Strategy 2 and detailed in Appendix Q2) across all ecosystem protection, restoration, and enhancement planning, design, and funding efforts.

Although major challenges exist in addressing the historical alteration of the Delta ecosystem, progress toward protecting existing conditions and restoring the Delta ecosystem has been made. Approximately 25,000 acres of habitat restoration is in progress pursuant to existing mandates under federal biological opinions to support native fish species, and an additional 5,000–10,000 acres of habitat restoration and enhancement projects have been funded by state-led programs (e.g., Delta Conservancy and CDFW grant programs). The pace of progress has also accelerated over recent years due to concerted efforts on behalf of the state administration to support additional resources to align state and federal activities, increase the efficiency of permitting processes, and focus on creating resources to complete projects. Nevertheless, there remains a pressing urgency to restore ecosystem function to ensure the Delta can remain a unique ecological resource and to increase the resiliency of the ecosystem to growing threats from subsidence, land-use changes, climate change, and sea level rise.

Increase Interagency Coordination and Support for Restoration Projects

Known barriers to implementing ecosystem restoration projects include restrictions on the amount and use of restoration funding, complex and time-intensive permitting requirements, and a lack of authority and funding to support long-term ownership and management of restoration projects. Addressing these challenges requires institutional commitment to a single, consolidated restoration forum with agency support and discretion to align strategies. The existing charter of the Delta Plan Interagency Implementation Committee (DPIIC) provides a framework for this type of effort, focused on implementing restoration projects (see New ER Recommendation “F”). The roles and responsibilities of relevant agencies, including DPIIC member agencies, for restoration in the Delta are shown in Table 4-1.

Funding

Based on the most recent available studies, the cost of restoring the Delta ecosystem is estimated at over five billion dollars, or several hundreds of millions of dollars annually (DWR 2013b, Medellín-Azuara et al. 2013). These studies estimate the cost of tidal wetland and shallow water habitat restoration (including land acquisition) at 20,000 dollars per acre, although costs can vary widely based on location, ownership, and project features. As of 2013, annual maintenance costs for tidal wetland restoration projects were estimated at 35 to 100 dollars per acre. Estimated capital and operations and maintenance costs for some direct fish management actions, invasive species control measures, and expansion of floodplain habitat, were about 10 million dollars per year; while actions related to changing flow management and reducing discharges ranged between 10 to 100 million dollars per year (Medellín-Azuara et al. 2013).

State agencies should collaborate to develop a comprehensive funding strategy that updates cost estimates and identifies a portfolio of approaches to remove institutional barriers to funding landscape-scale restoration projects within the Delta. Multi-benefit project funding is often limited in scope, and frequently must be used to achieve other project objectives in addition to ecosystem restoration. Bonds and public borrowing have funded the majority of large-scale restoration projects in the Delta to date, but gaps have been left with respect to the long-term management of restored lands. Planning efforts have typically focused on identifying and implementing the most cost-effective actions providing the highest ecological values for the lowest cost. The result of implementing the lowest-cost, highest-value projects is that remaining actions needed in the Delta will largely be of moderate to high cost (Medellín-Azuara et al. 2013). Achieving the Delta Plan’s vision for restoring Delta ecosystem will require different funding strategies and mechanisms than have been applied in the past.

These costs are necessary to achieve the ecosystem restoration goals, subgoals and strategies identified in the Delta Reform Act. Yet it is important to note that such large-scale investments in ecosystem restoration could also provide economic benefits to Delta communities, such as job creation, ecotourism, flood control, improved water quality, and improved commercial and recreational fisheries.

Permitting

Permitting for ecosystem protection, restoration, and enhancement actions in the Delta can be complex, time-consuming, and costly, requiring coordination among multiple local, state, and federal agencies. Strategic partnerships amongst agencies, including continued investment in fostering these relationships on an ongoing basis, will be important to help accelerate progress toward protecting, restoring, and enhancing the Delta ecosystem.

State and federal agencies should coordinate to establish program-level environmental permitting mechanisms that increase efficiency for priority projects, which are defined as projects that have at least four of the priority attributes of ecosystem restoration described in Core Strategy 2 and Appendix Q2. The DPIIC provides an existing forum in which state and federal agencies could coordinate Delta permitting needs and develop agreements to support integrated permitting processes, regional mitigation banking and crediting, and cost sharing. Such coordination would help increase the effectiveness of mitigation, shifting the focus from avoiding jeopardy toward species recovery and resilience, and reducing the time and cost for restoration projects to move to implementation.

Table 4-1. State and Federal Agency Responsibilities for Restoration in the Delta

Agency	Responsibility
California Department of Fish and Wildlife	Developed Delta Conservation Framework (Sloop et al. 2018), which is intended to serve as a comprehensive resource and guide for planning conservation in the Delta through 2050; funds and manages lands for ecosystem restoration and habitat conservation projects in the Delta; state permitting agency; implements the Ecosystem Restoration Program, a multiagency effort aimed at improving and increasing terrestrial and aquatic habitats and ecological function in the Delta and its tributaries.
California Department of Parks and Recreation	Owns and manages State Parks' property for the state, including in the Delta; develops and implements recreation plans; provides grant funding for parks and recreation projects.
California Department of Water Resources	Operates and maintains water management facilities and federally constructed flood control features within the Delta and Delta watershed; acquires and manages land; plans and implements multi-purpose projects that support ecosystem restoration and habitat conservation in the Delta; manages levee habitat mitigation and enhancement projects in the Delta.
California Natural Resources Agency	Coordinates and oversees the restoration-related activities of numerous state agencies charged with Delta Plan implementation, including California EcoRestore.
California State Lands Commission	Protects California's navigable waterways and submerged lands for public use and enjoyment; works with other state agencies and local and regional governments to assess risk and then plan accordingly.
California Water Commission	Distribution of public funds set aside for the public benefits of water storage projects, including ecosystems and fish and wildlife in the Delta, and developing regulations for the quantification and management of those benefits.
Central Valley Flood Protection Board	Adopts the Central Valley Flood Protection Plan, which prioritizes flood management projects for federal project levees in the Delta, has permitting authority and is the nonfederal sponsor on select flood control facilities in the Delta.
Delta Protection Commission	Manages the newly established Sacramento-San Joaquin Delta National Heritage Area; protects, maintains, enhances, and enriches the overall quality of the Delta environment and economy.
Delta Stewardship Council	Implements the Delta Plan, a comprehensive, long-term, legally enforceable management plan for the Delta; through the Delta Science Program, provides the best possible unbiased scientific information to inform water and environmental decision-making in the Delta; coordinates and guides adaptive management strategies through the *Delta Science Plan and the Interagency Adaptive Management Integration Team*; identifies funding for projects; produces syntheses and hosts symposia to inform restoration projects; conducts early consultation with project proponents for certification of consistency with the Delta Plan; processes certifications of consistency; hears and decides appeals; coordinates the Delta Plan Interagency Implementation Committee (DPIIC).
National Oceanic and Atmospheric Administration	National Marine Fisheries Service – Develops plans for the conservation and recovery of threatened and endangered anadromous fish; Ecosystem Restoration Program implementing agency; federal permitting agency. NOAA Office for Coastal Management – Collaborates with San Francisco State University and San Francisco Bay Conservation and Development Commission on the San Francisco Bay National Estuarine Research Reserve.

Table 4-1. Agency Responsibilities for Restoration in the Delta (contd.)

Agency	Responsibility
Sacramento-San Joaquin Delta Conservancy	Primary state agency for implementation of ecosystem restoration in the Delta; funds ecosystem restoration and habitat conservation projects in the Delta; has authority to acquire and manage lands and to coordinate with landowners; develops carbon market incentives and pilot projects.
San Francisco Bay Conservation and Development Commission	Administers the Suisun Marsh Protection Plan and ensures federal projects and activities are consistent with the plan as the federally designated state coastal management agency for San Francisco Bay.
San Francisco Bay Restoration Authority	Funds shoreline projects that protect, restore, and enhance San Francisco Bay, including Suisun Marsh and portions of Contra Costa and Solano Counties, through the allocation of funds raised by the Measure AA parcel tax.
State Water Resources Control Board	Establishes, implements, and enforces water-rights requirements; state permitting agency; with regional boards, develops and implements water quality standards and control plans, including the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (Bay-Delta Plan), which establishes water quality control measures and flow requirements needed to provide reasonable protection of beneficial uses in the watershed.
U.S. Army Corps of Engineers	Plans and implements multi-purpose projects that support aquatic ecosystem restoration in the Delta.
U.S. Bureau of Reclamation	Operates water management facilities within the Delta and Delta watershed; plans and implements multi-purpose projects that support ecosystem restoration and habitat conservation in the Delta.
U.S. Environmental Protection Agency	Oversees implementation of Clean Water Act programs and policies delegated to the State of California; published the San Francisco Bay Delta Action Plan in August 2012 and identified priority activities to advance the protection and restoration of aquatic resources and ensure a reliable water supply in the San Francisco Bay Delta Estuary watershed.
U.S. Fish and Wildlife Service	Develops plans for the conservation and recovery of threatened and endangered terrestrial and aquatic species; Ecosystem Restoration Program implementing agency; federal permitting agency.

PERMITTING AND REGULATORY PROCESSES THAT AID ECOSYSTEM RESTORATION

- **Regional Partnerships**. Habitat planning conducted through regional conservation frameworks, such as the California Department of Fish and Wildlife's *Delta Conservation Framework*, provides a means for identifying and reinforcing landscape-scale conservation targets and identifying permitting actions that may be needed at a program level.
- **California Environmental Quality Act**. Program-level coverage under CEQA for ecosystem restoration and related multi-benefit actions in the Delta could provide another tool to streamline implementation. For example, the *Suisun Marsh Habitat Management, Preservation, and Restoration Plan* and its Final Environmental Impact Statement/Environmental Impact Report guide and provide compliance support to implementing agencies in obtaining permits to carry out wetland restoration and management actions.
- **Advance Mitigation**. The California Department of Fish and Wildlife's *Regional Conservation Investment Strategies Program* moves a step beyond planning by incorporating advance mitigation credit components. Mitigation credit agreements developed under an approved Regional Conservation Investment Strategy provide the basis for creating and tracking mitigation credits when conservation or habitat enhancement actions are implemented. This voluntary, nonregulatory regional planning process is intended to result in higher-quality conservation outcomes, while facilitating regional mitigation.
- **Expedited Permitting**. The *Bay Restoration Regulatory Integration Team* seeks to reduce permitting time for multi-benefit restoration projects via coordinated permitting, while ensuring compliance with all applicable laws. A variety of agency partners have developed a programmatic Biological Assessment for the National Marine Fisheries Service to review, approve, and use to issue a programmatic Biological Opinion. The U.S. Army Corps of Engineers has also embarked on internal efforts to increase the efficiency of its Clean Water Act Section 404 Permit process. Similarly, the multi-agency *Suisun Marsh Adaptive Management Advisory Team* meets regularly to review projects within the Suisun Marsh during early planning, setting the stage for faster permit approvals when projects move into construction.

Ownership and Management

Improved coordination among public agencies is also needed to develop strategies for acquisition and long-term public ownership and management of lands necessary to achieve large-scale restoration in the Delta. Although the Council does not have the authority to construct, implement, or fund ecosystem protection, restoration, or enhancement actions, the Delta Reform Act created and granted authority to the Delta Conservancy to acquire and manage lands and to coordinate with landowners, among other responsibilities. This authority is critical to implementing restoration in the geographies and at the scale required. The DPIIC also has an important role to play in facilitating the development of cost-sharing agreements and other strategies to support ownership and maintenance of lands used by multiple partner agencies to accomplish restoration, recreation, and other objectives.

The Council acknowledges that land ownership and management can affect the productivity of existing agricultural operations, and the values of the Delta as an evolving place. Therefore, the Delta Plan contains a regulatory policy to promote ecosystem restoration on existing public lands before privately owned sites are purchased (see Chapter 5 for a detailed description of Delta As Place and DP P2). However, achieving the vision of a restored Delta ecosystem will require restoration on lands beyond those currently in public ownership. Reaching a balance between agriculture and a functioning ecosystem will require working landscapes—agricultural lands managed to support biodiversity and provide habitat resources—as an important part of achieving ecosystem goals in the Delta. Partnership strategies should incentivize the long-term management of working lands for ecosystem services such as seasonal wetland and floodplain habitat, carbon sequestration, and subsidence reversal.

Science Support

The Delta Reform Act requires that the Delta Plan "Include a science-based, transparent, and formal adaptive management strategy for ongoing ecosystem restoration and water management decisions" (Water Code section 85308[f]). Use of best available science and application of a robust, science-based adaptive management plan are essential for moving ecosystem restoration science forward, and for the long-term success of ecosystem restoration in the Delta (see Delta Plan Policy GP 1, subsections [b][3, 4] codified as 23 CCR section 5002[b][3,4]). Proponents of ecosystem protection, restoration, and enhancement projects should consult with the Delta Science Program on the application of best available science and adaptive management.

Extensive baseline data are needed to understand the effectiveness of restoration actions, to adaptively manage projects, and to improve restoration design in the future. For example, from 2017 to 2019, the Council funded Operation Baseline, an initiative to develop tools and collect additional data on the current state of nutrients, aquatic vegetation, and the food web in areas that may be affected by new wastewater treatment facilities.

Adaptive management of restoration projects should incorporate the use of experiments where possible to improve our understanding of restoration approaches and reduce future uncertainty. For example, a tidal wetland restoration project could include an experiment to test the effect of different bank slopes in otherwise similar locations. Lessons learned from adaptive management will be used to improve planning, design, and implementation of similar, future process-based restoration projects. Monitoring and adaptive management of restoration projects should be pursued over time scales that are sufficiently long to observe and adapt to changes in conditions. There may often be long time lags between implementing process-based restoration actions and seeing recovery of ecological processes (e.g., it takes many years for newly planted trees to grow into mature stands of riparian forest and even longer to observe recruitment from those trees) (Beechie et al. 2010). When adaptive management experiments are included in the design of ecosystem restoration projects (e.g., the Dutch Slough Tidal Marsh Restoration Project), future improvement in restoration design can be expected.

The Delta Science Program develops and implements the *Delta Science Plan* and the *Science Action Agenda* to strengthen, organize, and communicate science to provide relevant, credible, and legitimate decision-support for policy and management actions, and to identify priority actions that fill critical gaps in Delta science. The Delta Science Program aims to provide technical guidance, update and increase the accessibility of conceptual models, and develop standardized monitoring tools to facilitate both individual restoration projects and comparability and synthesis across projects (Council 2019).

State and federal agencies should coordinate with the Delta Science Program to align resources for scientific support of restoration efforts, including adaptive management, data tools, monitoring, synthesis, and communication.

Policies and Recommendations

Core Strategy 1: Create More Natural Functional Flows

The volume, timing, and extent of freshwater flows through the Delta directly affect the reliability of water supplies and the health of the Delta ecosystem. More natural functional flows across a restored landscape can support native species recovery, while providing the flexibility needed for water supply reliability. Freshwater flows should be allocated and adaptively managed to more closely resemble the natural volume, timing, frequency, and duration to achieve the desired ecosystem functions.

Implement and Regularly Update Flow Guidance

Problem Statement

The best available science demonstrates that altered or reduced water flows strain the entire Delta ecosystem, as well as the rest of the estuary. The predictability of water exports cannot be improved, and restoration cannot be effectively implemented, without timely State Water Resources Control Board action to update flow objectives. Updates must consider and balance the agricultural, urban, and ecosystem beneficial uses of a finite water supply and use best available science to guide decision-making.

Policy

ER P1. Delta Flow Objectives (NO CHANGE)

(a) The State Water Resources Control Board's Bay Delta Water Quality Control Plan flow objectives shall be used to determine consistency with the Delta Plan. If and when the flow objectives are revised by the State Water Resources Control Board, the revised flow objectives shall be used to determine consistency with the Delta Plan.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, the policy set forth in subsection (a) covers a proposed action that could significantly affect flow in the Delta.

Recommendation

ER R1. Update Delta Flow Objectives (REVISED)

The State Water Resources Control Board (SWRCB) should maintain a regular schedule of reviews of the Bay-Delta Plan to reflect changing conditions due to climate change and other factors. The SWRCB should consult with the Delta Science Program on adaptive management and the use of best available science.

Core Strategy 2: Restore Ecosystem Function

Achieving the Delta Reform Act vision for the Delta ecosystem requires the reestablishment of tens of thousands of acres of functional, diverse, and interconnected habitat. The magnitude of the need dictates a change in existing approaches to restoration in the Delta. State agencies will require new funding sources in order to implement large-scale restoration projects and support multi-benefit projects that go above and beyond mitigation of impacts. An integrated, adaptive approach to ecosystem restoration requires that restoration projects focus on ecosystem function and be designed and located to continue functioning under changing climate conditions. Restoration projects should also be compatible with adjacent land uses and support the cultural, recreational, agricultural, and natural resource values of the Delta as an evolving place.

Improve Project Design

Problem Statement

The loss of over 90 percent of wetlands greatly impacted the Delta ecosystem; further impacts across all ecosystem components (physical, chemical and biological) continue to severely stress the Delta ecosystem. Habitats and migration corridors in the Delta are already shifting with climate-driven impacts such as sea level rise and temperature changes, and these changes are likely to accelerate rapidly in coming decades. Restoration projects must be implemented at scales and in locations with sufficient opportunity to restore land-water connections in order to be resilient to these long-term trends. Currently, many restoration actions in the Delta are limited to single-species conservation, recovery, or mitigation projects. State agencies charged with stewardship and restoration of the Delta ecosystem have limited ability to change these practices due to permitting requirements and restrictions on the amount and use of public funds. Information gaps prevent more systematic planning and adaptive management of these activities and investments.

Policies

New ER Policy “A.” Disclose Contributions to Restoring Ecosystem Function and Providing Social Benefits (NEW)

(a) The certification of consistency for a covered action described in Subsection (b) shall include the completed following Sections in Appendix 3A, including all required information and documentation:

1. *Section 1 (Priority Attributes) of Appendix 3A (Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits) to demonstrate that the covered action has one or more of the priority attributes, to disclose its contribution to the restoration of a resilient, functioning Delta ecosystem, and to identify the ecosystem restoration tier associated with that covered action based on the identified priority attributes; and*
2. *Section 2 (Social Benefits) of Appendix 3A (Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits) to demonstrate and disclose the cultural, recreational, agricultural, and/or natural resource benefits anticipated to result from project implementation.*

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy applies to a covered action that includes protection, enhancement, or restoration of the ecosystem.

ER P4. Expand Floodplains and Riparian Habitats in Levee Projects (REVISED)

(a) Certifications of consistency for levee projects must provide an evaluation of, and where feasible the levee project must incorporate, alternatives to increase floodplains and riparian habitats.

1. *Levee projects located in the following areas (as depicted in Appendix 8A): (1) The Sacramento River between the Deepwater Ship Channel and Steamboat Slough, the San Joaquin River from the Stanislaus River confluence to Rough and Ready Island, the Stanislaus River, the Cosumnes River, Middle River, Old River, Paradise Cut, Elk Slough, Sutter Slough; and the North and South Forks of the Mokelumne River, and (2) Urban levee improvement projects in the cities of West Sacramento and Sacramento, shall evaluate alternatives which remove all or a portion of the original levee prism in order to physically expand the width of the channel.*

2. All levee projects located in whole or in part in the Delta shall evaluate alternatives to increase levee waterside habitat.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action to construct a new flood control work or make capital improvements to an existing flood control work.

Recommendations

New ER Recommendation “A.” Increase Public Funding for Restoring Ecosystem Function (NEW)

New funding sources are needed to achieve the scale of ecosystem restoration envisioned by the Delta Reform Act. Future State funding opportunities for implementing restoration projects in the Delta, including grant and loan programs, should be directed to projects that would achieve Ecosystem Restoration Tier 1 or 2, as defined in Appendix 3A.

New ER Recommendation “B.” Use Good Neighbor Checklist to Coordinate Restoration with Adjacent Uses (NEW)

Restoration project managers should use the Department of Water Resources’ Good Neighbor Checklist when planning and designing restoration projects, in order to demonstrate that the project avoids or reduces conflicts with existing uses.

ER R4. Exempt Delta Levees from the U.S. Army Corps of Engineers’ Vegetation Policy (NO CHANGE)

Considering the ecosystem value of remaining riparian and shaded riverine aquatic habitat along Delta levees, the U.S. Army Corps of Engineers should agree with the California Department of Fish and Wildlife and the California Department of Water Resources on a variance that exempts Delta levees from the U.S. Army Corps of Engineers’ levee vegetation policy where appropriate.

Core Strategy 3: Protect Land for Restoration and Safeguard Against Land Loss

As sea levels rise, opportunities for intertidal and floodplain restoration are shifting inland, toward the upland edges of the Delta. Restoration of tidal wetlands should focus on opportunities to create interconnected habitats, where elevations will support intertidal habitats into the future. Lands at elevations suitable for current and future restoration must be protected from development, and restoration projects must be designed and located with rising sea levels in mind. Consistent with State law, local and regional plans in the Delta must consider sea level rise as well as the loss of lands suitable for ecosystem restoration and the need to accommodate these landscape changes. State agencies must take action to reduce, halt, or reverse subsidence; and incentivize agricultural land management practices that support native wildlife and counter subsidence.

Protect Opportunities for Restoration

Problem Statement

The loss of lands suitable for restoration due to sea level rise and development jeopardizes efforts to restore ecosystem functions in the Delta. Levees, roads, and other infrastructure prevent wetland migration, threatening the ability of existing channel margin wetlands to adapt to rising sea levels. The expansion of development and infrastructure in the Delta will constrain opportunities to reconfigure and reconnect floodplains to their channels. Over time, these forces will continue to diminish the extent of land suitable for restoration projects at intertidal elevations, reducing future opportunities to create land-water connections and restore ecosystem function.

Policies

ER P2. Restore Habitats at Appropriate Elevations (REVISED)

(a) The certification of consistency for a covered action described in Subsection (d) must be carried out in a manner consistent with Appendix 4A, which provides guidance on appropriate elevations for particular ecosystem types within the Sacramento-San Joaquin Delta and Suisun Marsh.

1. *The certification of consistency must include a completed Appendix 4A and all of the documentation and information required by Appendix 4A.*
2. *If a covered action is not consistent with the Table 1.1 in Appendix 4A, the certification of consistency shall provide, based on best available science, the rationale for any inconsistency with Table 1.1 and how it is nonetheless consistent with this policy.*

(b) The certification of consistency for a covered action that takes place, in whole or in part, in the Intertidal Elevation Band and Sea Level Rise Accommodation Band shall, based on best available science:

1. *Explain, how the action is designed to accommodate each of the following:*
    - i. *future marsh migration;*
    - ii. *anticipated sea level rise; and*
    - iii. *tidal inundation; and*
2. *If the action does not implicate one or more of the elements set forth in subsection (1) of section (b) of this regulation, for each such element, explain why it does not.*
3. *The information required by this regulation may be included in an adaptive management plan, where required by section 5002 of this Chapter.*

(c) The certification of consistency for a covered action that takes place, in whole or in part, in the Shallow Subtidal Elevation Band or the Deep Subtidal Elevation Band shall explain, based on best available science, how the action is designed to safeguard against levee failure over the design life of the project. This information may be included in an adaptive management plan, where required by section 5002 of this Chapter.

(d) For purposes of Water Code Section 85057.5(a)(3) and Section 5001(j)(1)(E) of this Chapter, this policy applies to a covered action that includes protection, restoration, or enhancement of the ecosystem.

ER P3. Protect Opportunities to Restore Habitat (REVISED)

(a) Within the priority habitat restoration areas depicted in Appendix 5, significant adverse impacts to the opportunity to restore habitat as described in section 5006 of this Chapter, must be avoided or mitigated.

(b) Impacts referenced in subsection (a) will be deemed to be avoided or mitigated if the project is designed and implemented so that it will not preclude or otherwise interfere with the ability to restore habitat as described in section 5006 of this Chapter.

(c) If the impacts referenced in subsection (a) are mitigated (rather than avoided), they must be mitigated to the extent that the project has no significant impact on the opportunity to restore habitat as described in section 5006 of this Chapter.

(d) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions in the priority habitat restoration areas depicted in Appendix 5. It does not cover proposed actions outside those areas.*

Recommendation

ER R5. Update the Suisun Marsh Protection Plan (REVISED)

The San Francisco Bay Conservation and Development Commission should update the Suisun Marsh Protection Plan to adapt to sea level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act, and the Delta Plan, and support local government and districts with jurisdiction in the Suisun Marsh in amending their components of the Suisun Marsh Local Protection Program accordingly.

Safeguard Against Land Loss

Problem Statement

Agriculture has shaped the rich economy and rural culture of the Delta, although it has come at a cost: the loss of land-water connections. Without regular inundation, peat-rich Delta lands experience soil carbon loss and subsidence. The 2018 Natural and Working Lands Inventory attributed the majority of soil carbon loss in California to oxidation of organic soils in the Delta. The ongoing loss of land due to subsidence threatens the Delta Reform Act's vision for a restored Delta ecosystem, the livelihoods of those who live and work in the Delta, and statewide water supply reliability. Urgent action is needed to halt the current rapid pace of subsidence and to promote subsidence reversal activities. Reaching a holistic balance between agriculture and a functioning ecosystem will require working landscapes – agricultural lands managed to support biodiversity and provide habitat resources – as an important part of achieving ecosystem goals in the Delta. State agencies own more than 35,000 acres on deeply subsided lands in the Delta and Suisun Marsh and thus have a critical role to play in halting and reversing subsidence.

Recommendations

New ER Recommendation "C." Fund Targeted Subsidence Reversal Actions (NEW)

(a) *The Delta Conservancy should develop incentive programs for public and private land owners that encourage land management practices that stop subsidence on deeply subsided lands in the Delta and Suisun Marsh.*

(b) *In order to ensure the long-term durability of state investments in restoration, State agencies that fund ecosystem restoration in subsided areas should direct investments to areas that have opportunities to both reverse subsidence and restore intertidal marsh habitat.*

New ER Recommendation "D." Funding to Enhance Working Landscapes (NEW)

State agencies should be provided with funding in order to provide resources and support to Resource Conservation Districts (RCDs), and other local agencies and districts, in their efforts to restore ecosystem function or improve agricultural land management practices that support native species. State agencies should work with RCDs, and other local agencies and districts, to adaptively manage agricultural land management practices to improve habitat conditions for native species.

New ER Recommendation "E." Develop and Update Management Plans to Halt or Reverse Subsidence on Public Lands (NEW)

For all publicly-owned lands in the Delta or Suisun Marsh, State and local agencies should develop or update plans that identify land management goals; identify appropriate public or private uses for that property; and describe the operation and maintenance requirements needed to implement management goals. These plans should address subsidence and consider the feasibility of subsidence reversal.

Core Strategy 4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

While large-scale ecosystem restoration is the priority approach to support native species recovery, some stressors require more focused interventions. In particular, management actions continue to be necessary to avoid introductions of, and reduce the spread of, nonnative invasive species. In managing native fish populations, reestablishing riparian habitat and in-stream connectivity along migratory corridors supports the reproductive success and survival of native fish. Hatcheries and harvest regulation should employ adaptive management strategies to predict and evaluate outcomes and minimize risks.

Prevent Introduction of Nonnative Species and Manage Nonnative Species Impacts

Problem Statement

Nonnative invasive species are both a symptom of a highly degraded ecosystem and a major obstacle to successful restoration of the Delta ecosystem because they can affect the survival, health, and distribution of native Delta plants and wildlife. Native species are impacted by nonnative invasive species through competition, predation, disease and other interactions. The establishment of new nonnative invasive species is likely within the highly altered landscape of the Delta and could result in further ecosystem effects. Native species are also impacted by ongoing activities that improve habitat conditions for existing nonnative invasive species.

Policy

ER P5. Avoid Introductions of and Habitat Improvements for Invasive Nonnative Species (NO CHANGE)

(a) The potential for new introductions of or improved habitat conditions for nonnative invasive species, striped bass, or bass must be fully considered and avoided or mitigated in a way that appropriately protects the ecosystem.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that has the reasonable probability of introducing or improving habitat conditions for nonnative invasive species.

Recommendation

ER R7. Prioritize and Implement Actions to Control Nonnative Invasive Species (REVISED)

The Delta Conservancy, Delta Science Program, California Department of Fish and Wildlife, California Department of Food and Agriculture, California Department of Parks and Recreation, Division of Boating and Waterways, and other State and federal agencies should develop and implement communication and funding strategies to manage existing nonnative invasive species and for rapid response to new introductions of nonnative invasive species, based on scientific expertise and research.

Improve Fish Management

Problem Statement

Fish migration is impaired by barriers and unscreened diversions within and upstream of the Delta, and these impacts will be compounded with a rapidly changing climate. Aquatic habitat conditions within the Delta support nonnative, predatory fish species, further reducing native fish survival. Hatcheries and harvest regulation are important tools in fisheries management, but they also pose genetic and ecological risks to wild salmon runs, other native species, and the Delta ecosystem. These practices need to employ adaptive management strategies to predict and evaluate outcomes and minimize risks.

Recommendations

New ER Recommendation "H." Prioritize Unscreened Diversions within the Delta (NEW)

The California Department of Fish and Wildlife should collect field data to inform prioritization of unscreened diversions within the Delta.

New ER Recommendation "I." Fund Projects to Improve Survival of Juvenile Salmon (NEW)

Public agencies should fund and implement projects that improve aquatic habitat conditions and reduce predation risk for juvenile salmon along the priority migration corridors identified in Chapter 4, Figure 4-8. Projects that could improve survival of juvenile salmon include levee setbacks and waterside habitat improvements, placement of fish guidance structures, and nonnative aquatic weed management.

ER R8. Manage Hatcheries to Reduce Risk of Adverse Effects (REVISED)

All public agencies that manage hatcheries potentially affecting listed fish species should develop, or continue to develop, periodically update, and implement scientifically sound Hatchery and Genetic Management Plans (HGMPs) to reduce risks to Central Valley natural-origin and listed species.

ER R9. Coordinate Fish Migration and Survival Research (REVISED)

The California Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, should seek coordination among researchers studying fish migration pathways and survival within the Delta waterways to improve synthesis of results across research efforts.

Core Strategy 5: Improve Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement

A large and diverse array of public agencies and private organizations are engaged in ecosystem protection, enhancement, restoration, and mitigation in the Delta, with roles ranging from regulatory oversight to project implementation and long-term monitoring and management. Improving the efficiency and effectiveness of these efforts will require institutional commitment to a single, consolidated restoration forum with agency support and discretion to guide restoration strategies, plan investments, align individual agency plans and actions, and resolve barriers to implementation.

Increase Interagency Coordination and Support for Restoration Projects

Problem Statement

Broad, landscape scale changes are necessary to restore ecosystem functions in the Delta and Suisun Marsh. While coordination between State, federal and local agencies on ecosystem restoration has dramatically improved through forums such as the Delta Plan Interagency Implementation Committee and the Interagency Adaptive Management and Integration Team, slow progress in protecting and restoring the Delta ecosystem reveals an ongoing need to better coordinate plans and actions that contribute to ecosystem restoration.

Recommendations

New ER Recommendation "F." Support Implementation of Ecosystem Restoration (NEW)

Local, State and federal agencies should coordinate to support implementation of ecosystem restoration, and the Delta Plan Interagency Implementation Committee (DPIIC) should:

(a) *Consider establishing an ecosystem restoration subcommittee.*

(b) *Develop strategies for acquisition and long-term ownership and management of lands necessary to achieve ecosystem restoration consistent with the guidance in Appendix Q2.*

(c) *Develop a funding strategy that identifies a portfolio of approaches to remove institutional barriers and fund Ecosystem Restoration Tier 1 or 2 actions within the Delta.*

(d) *Establish program-level endangered species permitting mechanisms that increase efficiency for Ecosystem Restoration Tier 1 or 2 actions within the Delta and compatible ecosystem restoration projects within the Delta watershed.*

(e) *Coordinate with the Delta Science Program to align State, federal, and local resources for scientific support of restoration efforts, including adaptive management, data tools, monitoring, synthesis, and communication.*

(f) *Develop a landscape-scale strategy for recreational access to existing and future restoration sites, where appropriate and while maintaining ecological value.*

New ER Recommendation "G." Align State Restoration Plans and Conservation Strategies with the Delta Plan (NEW)

Agencies should coordinate, and the Delta Plan Interagency Implementation Committee (DPIIC) should consider establishing a subcommittee, to align State, local, or regional restoration strategies, plans or programs in the Delta to be consistent with the priority attributes described in Appendix Q2. These include:

(a) *The Delta Conservation Framework;*

(b) *The CVFPP Conservation Strategy;*

(c) *The Public Lands Strategy;*

(d) *Regional Conservation Investment Strategies;*

(e) *Regional Conservation Strategies or Partnerships; and.*

(f) *San Francisco Bay and Suisun Marsh Conservation Strategies, Investments and Partnerships, as appropriate.*

Performance Measures

<<See Appendix E>>

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Appendix C
Attachment C-1.2
Non-substantive Revisions to Proposed Delta Plan Chapter 4, Protect, Restore and Enhance the Delta Ecosystem Since May 2020

Appendix C
Attachment C-1.2

Non-substantive Revisions Since May 2020 to Proposed Delta Plan Chapter 4, Protect, Restore and Enhance the Delta Ecosystem

Page 4-43

The below map was revised to align with the correct dataset version, which was already incorporated into Appendix Q1.

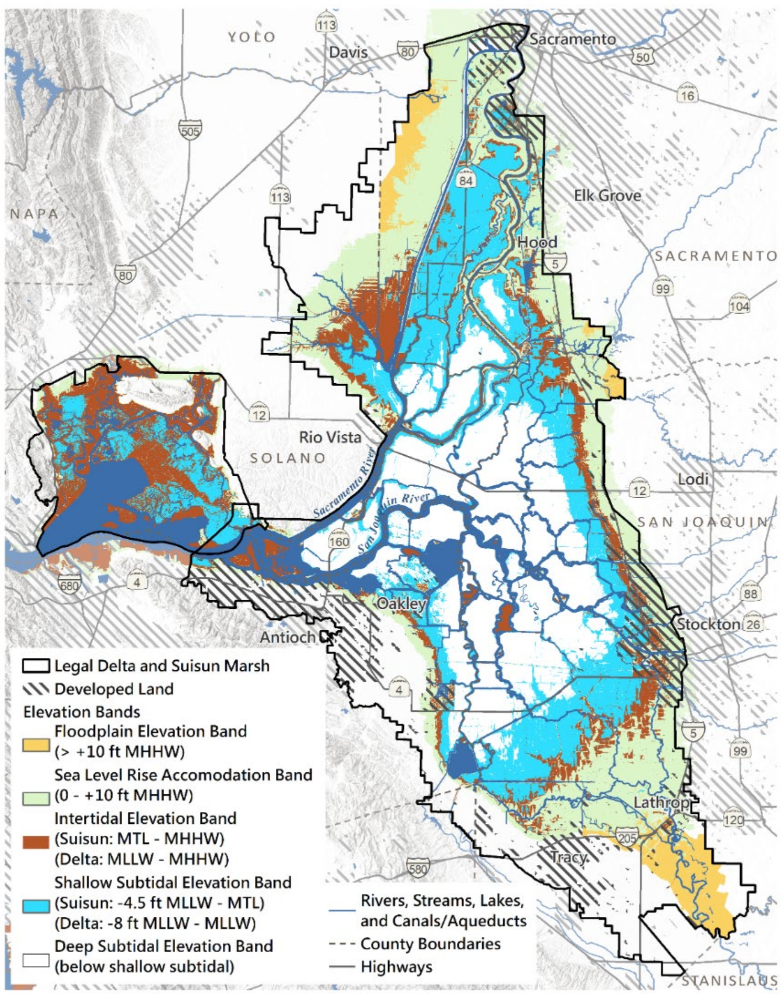

Figure 4-5
Elevation Bands for the Protection, Restoration, and Enhancement of Different Classes of Natural Communities

Page 4-6

The Delta also serves as a critical link between Sacramento Valley and San Joaquin Valley terrestrial wildlife populations. The Delta and its watershed provide a unique habitat resource for more than 200 species of marine and freshwater fish, as well as millions of migratory waterfowl and other migratory and resident birds (Council 2018a, Appendix Q4). Delta waterways help support California’s $1.5 billion commercial and recreational fishing industries (TNC 2017). Maintaining the Delta ecosystem is critical for supporting the 80 percent of commercial fishery species that migrate through or live in the Delta (Water Education Foundation 2019).

In a 1983 landmark legal decision, the California Supreme Court unanimously affirmed that the state’s navigable lakes and streams are resources that are held in trust for the public and are to be protected for navigation, commerce, fishing, recreational, ecological, and other public values. The State “has an affirmative duty to take the public trust into account in the planning and allocation of water resources and to protect public trust uses whenever feasible” (*National Audubon Society v. Superior Court*, 33 Cal. 3d 419, 658 P.2d 709, 189 Cal. Rptr. 346, 1983 Cal.). The Public Trust Doctrine is applicable to the Delta watershed. The coequal goal of protecting, restoring, and enhancing the Delta ecosystem is consistent with the Public Trust Doctrine and, among other things, promotes and protects fishing, recreational, and ecological public trust uses in the Delta watershed.

Page 4-28, Figure 4-3 caption

This figure illustrates functional flows that have sufficient magnitude, duration, frequency, and timing to affect river geomorphology, native species, and ecosystem processes. The solid beige areas illustrate a hypothetical unimpaired flow regime. The solid green areas illustrate how flow alterations such as water storage and diversion create more stable flows that do not have the characteristics needed to support geomorphic and ecosystem processes. The hatched blue areas depict flow augmentation through releases from storage or reduced diversions to mimic key elements of the natural flow regime. **All three hydrographs are fully displayed. The functional flow hydrograph represents a combination of the altered flow regime and the functional flows.**

Source: Mount et al. 2019. Reprinted with permission from the Public Policy Institute of California (PPIC).

Page 4-35, end of second paragraph

Project proponents should use the ~~California Department of Water Resources (DWR)~~ Good Neighbor Checklist **in the**~~when~~ planning and design~~ing~~ **of** restoration projects in order to ~~demonstrate that projects~~ avoid or reduce conflicts with existing uses (see New ER Recommendation “B**” and Appendix Q2**).

Page 4-60, beginning of third paragraph

An existing mechanism for coordination ~~between~~ among the agencies responsible for implementation of ecosystem protection, restoration, and enhancement actions and the Council is the early consultation process for covered action certification.

Page 4-70

New ER Policy "A." Disclose Contributions to Restoring Ecosystem Function and Providing Social Benefits (NEW)

(a) **A complete**~~The~~ certification of consistency for a covered action described in Subsection (b) shall **disclose and** include **all of the information and documentation required by** the ~~completed~~ following Sections in Appendix 3A~~, including all required information and documentation~~:

1. Section 1 (Priority Attributes) of Appendix 3A (Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits) to demonstrate that the covered action has one or more of the priority attributes, to disclose its contribution to the restoration of a resilient, functioning Delta ecosystem, and to identify the ~~e~~**E**cosystem ~~r~~**R**estoration ~~t~~**T**ier associated with that covered action based on the identified priority attributes; and
2. Section 2 (Social Benefits) of Appendix 3A (Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits) to demonstrate and disclose the cultural, recreational, agricultural, and/or natural resource benefits anticipated to result from project implementation.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy applies to a covered action that includes protection, enhancement, or restoration of the ecosystem.

Page 4-70

ER P4. Expand Floodplains and Riparian Habitats in Levee Projects (REVISED)

(a) Certifications of consistency for levee projects must **evaluate**~~provide an evaluation of~~, and where feasible ~~the levee project must~~ incorporate **into the levee project**~~,~~ alternatives **that would**~~to~~ increase floodplains and riparian habitats.

1. Levee projects located in the following areas (as depicted in Appendix 8A): (1) The Sacramento River between the Deepwater Ship Channel and Steamboat Slough, the San Joaquin River from the Stanislaus River confluence to Rough and Ready Island, the Stanislaus River, the Cosumnes River, Middle River, Old River, Paradise Cut, Elk Slough, Sutter Slough; and the North and South Forks of the Mokelumne River, and (2) Urban levee improvement projects in the cities of West Sacramento and Sacramento, shall evaluate alternatives **that would**~~which~~ remove all or a portion of the

original levee prism in order to physically expand the width of the channel.

2. All levee projects located in whole or in part in the Delta shall evaluate alternatives **that would**~~to~~ increase levee waterside habitat.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action to construct a new flood control work or make **a permanent structural change or improvement that enhances a flood control work's function, changes its level of protection, or adapts it for new or different use**~~capital improvements to an existing flood control work~~.

Page 4-71

New ER Recommendation "B." Use Good Neighbor Checklist to Coordinate Restoration with Adjacent Uses (NEW)

Restoration project**s** ~~managers~~ should use the ~~Department of Water Resources'~~ Good Neighbor Checklist **in the**~~when~~ planning and design~~ing~~ **of** restoration projects, in order to ~~demonstrate that the project~~ avoid~~s~~ or reduce~~s~~ conflicts with existing uses.

Page 4-74

New ER Recommendation "D." Funding to Enhance Working Landscapes (NEW)

State agencies should be provided with funding in order to provide resources and support to Resource Conservation Districts (RCDs), **Reclamation Districts (RDs),** and other local agencies and districts, in their efforts to restore ecosystem function or improve agricultural land management practices that support native species. State agencies should work with RCDs, **RDs,** and other local agencies and districts, to adaptively manage agricultural land management practices to improve habitat conditions for native species.

Page 4-75

New ER Recommendation "E." Develop and Update Management Plans to Halt or Reverse Subsidence on Public Lands (NEW)

For all publicly-owned lands in the Delta or Suisun Marsh, State and local agencies**, including Reclamation Districts,** should develop or update plans that identify land management goals; identify appropriate public or private uses for that property; and describe the operation and maintenance requirements needed to implement management goals. These plans should address subsidence and consider the feasibility of subsidence reversal.

Page 4-77

ER R9. Coordinate Fish Migration and Survival Research (REVISED)

The California Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, should seek coordination among researchers studying **juvenile anadromous** fish migration pathways and survival **upstream of, and** within the Delta waterways to improve synthesis of results across research efforts **and application to adaptive management actions**.

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Appendix C
Attachment C-1.3
In-Line Edits of Proposed Revisions to Delta Plan Chapter 4, Protect, Restore and Enhance the Delta Ecosystem Policies and Recommendations

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In-Line Edits of Proposed Revisions to Delta Plan Chapter 4, Protect, Restore and Enhance the Delta Ecosystem Policies and Recommendations

Core Strategy 1: Create More Natural Functional Flows

The volume, timing, and extent of freshwater flows through the Delta directly affect the ~~reliability of water supplies and the~~ health of the Delta ecosystem. More natural functional flows across a restored landscape can support native species recovery, while providing the flexibility needed for water supply reliability. Freshwater flows should be allocated and adaptively managed to more closely resemble the natural volume, timing, frequency, and duration needed to achieve the desired ecosystem functions. ~~Water flow in the Delta is critically important because flow affects the reliability of water supplies and the health of the Delta ecosystem. The best available science demonstrates that flow management is essential to restoration of the Delta ecosystem. Several important ecosystem stressors, including entrainment, are linked to altered water flows. Greater reverse flows in the south Delta increase the numbers of fish entrained.~~

Implement and Regularly Update Flow Guidance

Problem Statement

The best available science demonstrates that altered or reduced water flows strain the entire Delta ecosystem, as well as the rest of the estuary. The predictability of water exports cannot be improved, and restoration cannot be effectively implemented, without timely State Water Resources Control Board action to update flow objectives. Updates must consider and balance the agricultural, urban, and ecosystem beneficial uses of a finite water supply and use best available science to guide decision-making. ~~Altered flows in the Sacramento and San Joaquin rivers and their tributaries change flows within and out of the Delta, and affect salinity and sediment in the Delta. Fish and other aquatic species native to the Delta are adapted to natural flow, salinity, and sediment regimes. Current flow, salinity, and sediment regimes harm native aquatic species and encourage nonnative species. The best available science suggests that currently required flow objectives within and out of the Delta are insufficient to protect the Delta ecosystem (SWRCB 2010). Additionally, uncertainty regarding future flow objectives for the Delta impairs the~~

~~reliability of water supplies that depend on the Delta or its watershed. The predictability of water exports cannot be improved, and restoration cannot be implemented without timely SWRCB action to update flow objectives.~~

Policy

ER P1. Delta Flow Objectives

(a) *The State Water Resources Control Board's Bay Delta Water Quality Control Plan flow objectives shall be used to determine consistency with the Delta Plan. If and when the flow objectives are revised by the State Water Resources Control Board, the revised flow objectives shall be used to determine consistency with the Delta Plan.*

(b) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, the policy set forth in subsection (a) covers a proposed action that could significantly affect flow in the Delta.*

Recommendation

ER R1. Update Delta Flow Objectives

~~Development, implementation, and enforcement of the update to the Bay Delta Water Quality Control Plan is key to the achievement of the coequal goals.~~ The State Water Resources Control Board ***(SWRCB)*** *should* ***maintain a regular schedule of reviews of****~~update~~ the Bay Delta ~~Water Quality Control~~ Plan* ***to reflect changing conditions due to climate change and other factors. The SWRCB should consult with the Delta Science Program on adaptive management and the use of best available science.*** *~~objectives as follows:~~*

~~(a) By June 2, 2014, adopt and implement updated flow objectives for the Delta that are necessary to achieve the coequal goals.~~

~~(b) By June 2, 2018, adopt, and as soon as reasonably possible, implement flow objectives for high-priority tributaries in the Delta watershed that are necessary to achieve the coequal goals.~~[1]

~~Flow objectives could be implemented through several mechanisms including negotiation and settlement, Federal Energy Regulatory Commission relicensing, or adjudicative proceeding.~~[2]

~~Prior to the establishment of revised flow objectives identified above, the existing Bay Delta Water Quality Control Plan objectives shall be used to determine consistency with the Delta Plan. After the flow objectives are revised, the revised objectives shall be used to determine consistency with the Delta Plan.~~

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[1] ~~SWRCB staff should work with the Council and DFW to determine priority streams. As an illustrative example, priority streams could include the Merced River, Tuolumne River, Stanislaus River, Lower San Joaquin River, Deer Creek (tributary to Sacramento River), Lower Butte Creek, Mill Creek (tributary to Sacramento River), Cosumnes River, and American River. Implementation through hearings is expected to take longer than the deadline shown here.~~

[2] ~~Implementation through adjudicative proceedings or FERC relicensing is expected to take longer than the deadline shown here.~~

Core Strategy 2: Restore Ecosystem Function~~Habitat~~

Achieving the Delta Reform Act vision for the Delta ecosystem requires the reestablishment of tens of thousands of acres of functional, diverse, and interconnected habitats. The magnitude of the need dictates a change in existing approaches to restoration in the Delta. State agencies ~~will require~~ need new funding sources ~~in order~~ to implement large-scale restoration projects and support multi-benefit projects that go above and beyond mitigation of impacts.~~Loss of habitat is one of the largest stressors to the Delta ecosystem. The Delta Plan adopts the approach of the multiagency ERP Conservation Strategy (DFG 2011), which includes a map and accompanying text identifying appropriate habitat restoration types within the Delta and Suisun Marsh based on land elevation, included in the Delta Plan within Appendix B. Delta Plan Figure 4-6 is based on the ERP Conservation Strategy map. Policy ER P3 requires habitat restoration actions to use this figure and accompanying text (see Appendix B for additional information). For example, restoring tidal marsh habitat would generally not be appropriate outside the areas labeled "intertidal" on Figure 4-6 unless they connect other tidal marshes into large habitat areas or can recover elevation over time by natural processes.~~ **Under an** integrated, adaptive approach to **ecosystem restoration requires that restoration projects focus on ecosystem function and are designed and located to continue functioning under changing climate conditions.** ~~restoring habitat must address several issues. Each problem statement below highlights one of these issues, followed by specific policies and recommendations intended to address it.~~ **Restoration projects should also be compatible with adjacent land uses and support the cultural, recreational, agricultural, and natural resource values of the Delta as an evolving place.**

Improve Project Design

Problem Statement

The loss of over 90 percent of wetlands greatly impacted the Delta ecosystem; further impacts across all ecosystem components (physical, chemical and biological) continue to severely stress the Delta ecosystem. Habitats and migration corridors in the Delta are already shifting with climate-driven impacts such as sea level rise and temperature changes, and these changes are likely to accelerate rapidly in coming decades. Restoration projects must be implemented at scales and in locations with sufficient opportunity to restore land-water connections in order to be resilient to these long-term trends. Currently, many restoration actions in the Delta are limited to single-species conservation, recovery, or mitigation projects. State agencies charged with stewardship and restoration of the Delta ecosystem have limited ability to change these practices due to permitting requirements and restrictions on the amount and use of public funds. Information gaps prevent more systematic planning and adaptive management of these activities and investments.~~Features of the Delta landscape, particularly the condition of its waterways, the elevation of its land, and other environmental conditions, have changed dramatically over the past~~

~~160 years. Damage to the habitats that support native species in the Delta has led to declines in native animal and plant populations, affecting both resident and migratory species.~~

Policies

New ER Policy "A". Disclose Contributions to Restoring Ecosystem Function and Providing Social Benefits

(a) ~~The~~ A complete certification of consistency for a covered action described in Subsection (b) shall disclose and include all of the information and documentation required by the following Sections in Appendix 3A:

1. ***~~Include completed~~ Section 1 (Priority Attributes) of Appendix 3A (Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits) to demonstrate that the covered action has one or more of the priority attributes, to disclose its contribution to the restoration of a resilient, functioning Delta ecosystem, and to identify the Ecosystem Restoration Tier associated with that covered action based on the identified priority attributes; and***
2. ***~~Include completed~~ Section 2 (Social Benefits) of Appendix 3A (Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits) to demonstrate and disclose the cultural, recreational, agricultural, and/or natural resource benefits anticipated to result from project implementation.***

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy applies to a covered action that includes protection, enhancement, or restoration of the ecosystem.

[ER P2 and ER P3 moved to Core Strategy 3]

~~**ER P2. Restore Habitats at Appropriate Elevations**~~

~~*(a) Habitat restoration must be carried out consistent with Appendix 3, which is Section II of the Draft Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions (California Department of Fish and Wildlife 2011). The elevation map attached as Appendix 4 should be used as a guide for determining appropriate habitat restoration actions based on an area's elevation. If a proposed habitat restoration action is not consistent with Appendix 4, the proposal shall provide rationale for the deviation based on best available science.*~~

~~*(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that includes habitat restoration.*~~

~~ER P3. Protect Opportunities to Restore Habitat~~

~~(a) Within the priority habitat restoration areas depicted in Appendix 5, significant adverse impacts to the opportunity to restore habitat as described in section 5006, must be avoided or mitigated.~~

~~(b) Impacts referenced in subsection (a) will be deemed to be avoided or mitigated if the project is designed and implemented so that it will not preclude or otherwise interfere with the ability to restore habitat as described in section 5006.~~

~~(c) Impacts referenced in subsection (a) shall be mitigated to a point where the impacts have no significant effect on the opportunity to restore habitat as described in section 5006. Mitigation shall be determined, in consultation with the California Department of Fish and Wildlife, considering the size of the area impacted by the covered action and the type and value of habitat that could be restored on that area, taking into account existing and proposed restoration plans, landscape attributes, the elevation map shown in Appendix 4, and other relevant information about habitat restoration opportunities of the area.~~

~~(d) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions in the priority habitat restoration areas depicted in Appendix 5. It does not cover proposed actions outside those areas.~~

ER P4. Expand Floodplains and Riparian Habitats in Levee Projects

(a) **Certifications of consistency for** ~~L~~**l**evee projects must **~~provide an evaluation~~**evaluate **~~of,~~** and where feasible **~~the levee project must~~** incorporate **into the levee** project alternatives~~, including the use of setback levees, to~~ **that would** increase floodplains and riparian habitats. ~~Evaluation of setback levees in the Delta shall be required only in the following areas (shown in Appendix 8):~~

1. **Levee projects located in the following areas (as depicted in Appendix 8A): (1)** The Sacramento River between **the Deepwater Ship Channel and Steamboat Slough**~~Freeport and Walnut Grove~~, the San Joaquin River from the **Stanislaus River confluence to Rough and Ready Island**~~Delta boundary to Mossdale~~, **the Stanislaus River, the Cosumnes River, Middle River, Old River,** Paradise Cut, **Elk Slough**~~Steamboat Slough~~, Sutter Slough; and the North and South Forks of the Mokelumne River, and (2) Urban levee improvement projects in the cities of West Sacramento and Sacramento**, shall evaluate alternatives ~~which~~ that would remove all or a portion of the original levee prism in order to physically expand the width of the channel**.
2. **All levee projects located in whole or in part in the Delta shall evaluate alternatives to increase levee waterside habitat.**

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action to construct **a** new **flood control work**~~levees~~ or **make a permanent**

structural change or improvement that enhances a flood control work's function, changes its level of protection, or adapts it for new or different use ~~*substantially rehabilitate or reconstruct existing levees.*~~

Recommendations

New ER Recommendation "A". Increase Public Funding for Restoring Ecosystem Function

New funding sources are needed to achieve the scale of ecosystem restoration envisioned by the Delta Reform Act. Future State funding opportunities for implementing restoration projects in the Delta, including grant and loan programs, should be directed to projects that would achieve Ecosystem Restoration Tier 1 or 2, as defined in Appendix 3A.

New ER Recommendation "B". Use Good Neighbor Checklist to Coordinate Restoration with Adjacent Uses

Restoration projects ~~***managers***~~ ***should use the*** ~~***Department of Water Resources'***~~ ***Good Neighbor Checklist*** ~~***when***~~ ***in the planning and designing of restoration projects, in order to avoid or reduce conflicts*** ~~***demonstrate that the project avoids or reduces conflicts***~~ ***with existing uses.***

~~**ER R2. Prioritize and Implement Projects that Restore Delta Habitat**~~

~~*Bay Delta Conservation Plan implementers, California Department of Fish and Wildlife, California Department of Water Resources, and the Delta Conservancy should prioritize and implement habitat restoration projects in the areas shown on Figure 4-8. Habitat restoration projects should ensure connections between areas being restored and existing habitat areas and other elements of the landscape needed for the full life cycle of the species that will benefit from the restoration project. Where possible, restoration projects should also emphasize the potential for improving water quality. Restoration project proponents should consult the California Department of Public Health's*~~ ~~Best Management Practices for Mosquito Control in California~~~~*.*~~

- ~~***Yolo Bypass.*** *Enhance the ability of the Yolo Bypass to flood more frequently to provide more opportunities for migrating fish, especially Chinook salmon, to use this system as a migration corridor that is rich in cover and food.*~~
- ~~***Cache Slough Complex.*** *Create broad nontidal, freshwater, emergent-plant-dominated wetlands that grade into tidal fresh-water wetlands, and shallow subtidal and deep open-water habitats. Also, return a significant portion of the region to uplands with vernal pools and grasslands.*~~
- ~~***Cosumnes River–Mokelumne River confluence.*** *Allow these unregulated and minimally regulated rivers to flood over their banks during winter and spring frequently and regularly to create seasonal floodplains and riparian habitats that grade into tidal marsh and shallow subtidal habitats.*~~

- ***Lower San Joaquin River floodplain.*** *Reconnect the floodplain and restore more natural flows to stimulate food webs that support native species. Integrate habitat restoration with flood management actions, when feasible.*
- ***Suisun Marsh.*** *Restore significant portions of Suisun Marsh to brackish marsh with land-water interactions to support productive, complex food webs to which native species are adapted and to provide space to adapt to rising sea level action. Use information from adaptive management processes during the Suisun Marsh Habitat Management, Preservation, and Restoration Plan's implementation to guide future habitat restoration projects and to inform future tidal marsh management.*
- ***Western Delta/Eastern Contra Costa County.*** *Restore tidal marsh and channel margin habitat at Dutch Slough and western islands to support food webs and provide habitat for native species.*

ER R3. Complete and Implement Delta Conservancy Strategic Plan

As part of its Strategic Plan and subsequent Implementation Plan or annual work plans, the Delta Conservancy should:

- *Develop and adopt criteria for prioritization and integration of large-scale ecosystem restoration in the Delta and Suisun Marsh, with sustainability and use of best available science as foundational principles.*
- *Develop and adopt processes for ownership and long-term operations and management of land in the Delta and Suisun Marsh acquired for conservation or restoration.*
- *Develop and adopt a formal mutual agreement with the California Department of Water Resources, California Department of Fish and Wildlife, federal interests, and other State and local agencies on implementation of ecosystem restoration in the Delta and Suisun Marsh.*
- *Develop, in conjunction with the Wildlife Conservation Board, the California Department of Water Resources, California Department of Fish and Wildlife, Bay Delta Conservation Plan implementers, and other State and local agencies, a plan and protocol for acquiring the land necessary to achieve ecosystem restoration consistent with the coequal goals and the Ecosystem Restoration Program Conservation Strategy.*
- *Lead an effort, working with State and federal fish agencies, to investigate how to better use habitat credit agreements to provide credit for each of these steps: (1) acquisition for future restoration; (2) preservation, management, and enhancement of existing habitat; (3) restoration of habitat; and (4) monitoring and evaluation of habitat restoration projects.*
- *Work with the California Department of Fish and Wildlife and the U.S. Fish and Wildlife Service to develop rules for voluntary safe harbor agreements with property owners in the Delta whose actions contribute to the recovery of listed threatened or endangered species.*

Problem Statement

~~Current USACE policy requires removal of vegetation from Delta levees, which would reduce already sparse riparian and shaded aquatic habitat along the channels.~~

~~**Recommendation**~~

ER R4. Exempt Delta Levees from the U.S. Army Corps of Engineers' Vegetation Policy

Considering the ecosystem value of remaining riparian and shaded riverine aquatic habitat along Delta levees, the U.S. Army Corps of Engineers should agree with the California Department of Fish and Wildlife and the California Department of Water Resources on a variance that exempts Delta levees from the U.S. Army Corps of Engineers' levee vegetation policy where appropriate.

~~**Problem Statement**~~

~~The SMPP and the Local Protection Program components of the SMPP do not yet include climate change provisions. Without these amendments, it is unclear if and how Suisun Marsh will be managed to adapt to rising sea level.~~

~~**Recommendation**~~

[ER R5 moved to Core Strategy 3]

~~**ER R5. Update the Suisun Marsh Protection Plan**~~

~~*The San Francisco Bay Conservation and Development Commission should update the Suisun Marsh Protection Plan and relevant components of the Suisun Marsh Local Protection Program to adapt to sea level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act, and the Delta Plan.*~~

Core Strategy 3: <u>Protect Land for Restoration and Safeguard Against Land Loss</u>~~Improve Water Quality to Protect the Ecosystem~~

<u>**As sea levels rise and subsidence continues, opportunities for intertidal and floodplain restoration are shifting inland, toward the upland edges of the Delta. Restoration of tidal wetlands should focus on opportunities to create interconnected habitats, where elevations will support intertidal habitats into the future. Lands at elevations suitable for current and future restoration must be protected from development, and restoration projects must be designed and located with rising sea levels in mind. Consistent with State law, local and regional plans in the Delta must consider sea level rise as well as the loss of lands suitable for ecosystem restoration and the need to accommodate these landscape changes. State agencies must take action to reduce, halt, or reverse subsidence; and incentivize agricultural land management practices that support native wildlife and counter subsidence.**</u>~~Chapter 6 includes recommendations about salinity and ecosystem water quality. These recommendations support the protection of~~

~~water quality for all beneficial uses of water and encourage the identification of water quality impacts of proposed actions. The recommendations also address acceleration of certain total maximum daily loads, low dissolved oxygen, implementation of a Delta Regional Monitoring Program, treatment of wastewater effluent and urban runoff, and Regional Water Quality Control Board engagement in Suisun Marsh.~~

Protect Opportunities for Restoration

Problem Statement

The loss of lands suitable for restoration due to sea level rise and development jeopardizes efforts to restore ecosystem functions in the Delta. Levees, roads, and other infrastructure prevent wetland migration, threatening the ability of existing channel margin wetlands to adapt to rising sea levels. The expansion of development and infrastructure in the Delta will constrain opportunities to reconfigure and reconnect floodplains to their channels. Over time, these forces will continue to diminish the extent of land suitable for restoration projects at intertidal elevations, reducing future opportunities to create land-water connections and restore ecosystem function.~~The Delta ecosystem is impaired by pollutants from municipal, industrial, agricultural, and other discharges and legacy pollutants flowing into the Delta and its tributaries, including pollutants that bioaccumulate and biomagnify in the food web.~~

Policies

[ER P2 and ER P3 moved from Core Strategy 3]

ER P2. Restore Habitats at Appropriate Elevations

(a) The certification of consistency for a covered action described in Subsection (d) must be carried out in a manner consistent with Appendix 4A, which provides guidance on appropriate elevations for particular ecosystem types within the Sacramento-San Joaquin Delta and Suisun Marsh.

1. The certification of consistency must include a completed Appendix 4A and all of the documentation and information required by Appendix 4A.

2. If a covered action is not consistent with the Table 1.1 in Appendix 4A, the certification of consistency shall provide, based on best available science, the rationale for any inconsistency with Table 1.1 and how it is nonetheless consistent with this policy.

(b) The certification of consistency for a covered action that takes place, in whole or in part, in the Intertidal Elevation Band and Sea Level Rise Accommodation Band shall, based on best available science:

1. Explain, how the action is designed to accommodate each of the following:

i. future marsh migration;

ii. anticipated sea level rise; and
iii. tidal inundation; and

2. If the action does not implicate one or more of the elements set forth in subsection (1) of section (b) of this regulation, for each such element, explain why it does not.

3. The information required by this regulation may be included in an adaptive management plan, where required by section 5002 of this Chapter.

(c) The certification of consistency for a covered action that takes place, in whole or in part, in the Shallow Subtidal Elevation Band or the Deep Subtidal Elevation Band shall explain, based on best available science, how the action is designed to safeguard against levee failure over the design life of the project. This information may be included in an adaptive management plan, where required by section 5002 of this Chapter.

(d) For purposes of Water Code Section 85057.5(a)(3) and Section 5001(j)(1)(E) of this Chapter, this policy applies to a covered action that includes protection, restoration, or enhancement of the ecosystem.

~~(a) Habitat restoration must be carried out consistent with Appendix 3, which is Section II of the Draft Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions (California Department of Fish and Wildlife 2011). The elevation map attached as Appendix 4 should be used as a guide for determining appropriate habitat restoration actions based on an area's elevation. If a proposed habitat restoration action is not consistent with Appendix 4, the proposal shall provide rationale for the deviation based on best available science.~~

~~(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that includes habitat restoration.~~

ER P3. Protect Opportunities to Restore Habitat

(a) *Within the priority habitat restoration areas depicted in Appendix 5, significant adverse impacts to the opportunity to restore habitat as described in section 5006* ***of this Chapter****, must be avoided or mitigated.*

(b) Impacts referenced in subsection (a) will be deemed to be avoided or mitigated if the project is designed and implemented so that it will not preclude or otherwise interfere with the ability to restore habitat as described in section 5006 ***of this Chapter****.*

(c) ***If the impacts***~~*Impacts*~~ *referenced in subsection (a)* ***are***~~*shall be*~~ *mitigated* ***(rather than avoided), they must be mitigated to the extent that the project has***~~*to a point where the impacts have*~~ *no significant* ***impact***~~*effect*~~ *on the opportunity to restore habitat as described in section 5006* ***of this Chapter****.* ~~*Mitigation shall be determined, in consultation with the California*~~

~~*Department of Fish and Wildlife, considering the size of the area impacted by the covered action and the type and value of habitat that could be restored on that area, taking into account existing and proposed restoration plans, landscape attributes, the elevation map shown in Appendix 4, and other relevant information about habitat restoration opportunities of the area.*~~

(d) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions in the priority habitat restoration areas depicted in Appendix 5. It does not cover proposed actions outside those areas.

Recommendation~~s~~

~~*Recommendations for improving ecosystem water quality are included in Chapter 6.*~~

[ER R5 moved from Core Strategy 3]

ER R5. Update the Suisun Marsh Protection Plan

*The San Francisco Bay Conservation and Development Commission should update the Suisun Marsh Protection Plan ~~and relevant components of the Suisun Marsh Local Protection Program~~ to adapt to sea level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act, and the Delta Plan**, and support local government and districts with jurisdiction in the Suisun Marsh in amending their components of the Suisun Marsh Local Protection Program accordingly**.*

Safeguard Against Land Loss

Problem Statement

Agriculture has shaped the rich economy and rural culture of the Delta, although it has come at a cost: the loss of land-water connections. Without regular inundation, peat-rich Delta lands experience soil carbon loss and subsidence. The 2018 Natural and Working Lands Inventory attributed the majority of soil carbon loss in California to oxidation of organic soils in the Delta. The ongoing loss of land due to subsidence threatens the Delta Reform Act's vision for a restored Delta ecosystem, the livelihoods of those who live and work in the Delta, and statewide water supply reliability. Urgent action is needed to halt the current rapid pace of subsidence and to promote subsidence reversal activities. Reaching a holistic balance between agriculture and a functioning ecosystem will require working landscapes – agricultural lands managed to support biodiversity and provide habitat resources – as an important part of achieving ecosystem goals in the Delta. State agencies own more than 35,000 acres on deeply subsided lands in the Delta and Suisun Marsh and thus have a critical role to play in halting and reversing subsidence.

Recommendations

New ER Recommendation "C". Fund Targeted Subsidence Reversal Actions

(a) ***The Delta Conservancy should develop incentive programs for public and private landowners that encourage land management practices that stop subsidence on deeply subsided lands in the Delta and Suisun Marsh.***

(b) ***In order to ensure the long-term durability of state investments in restoration, State agencies that fund ecosystem restoration in subsided areas should direct investments to areas that have opportunities to both reverse subsidence and restore intertidal marsh habitat.***

New ER Recommendation "D". Funding to Enhance Working Landscapes

State agencies should be provided with funding in order to provide resources and support to Resource Conservation Districts (RCDs), Reclamation Districts (RDs), and other local agencies and districts, in their efforts to restore ecosystem function or improve agricultural land management practices that support native species. State agencies should work with RCDs, RDs, and other local agencies and districts, to adaptively manage agricultural land management practices to improve habitat conditions for native species.

New ER Recommendation "E". Develop and Update Management Plans to Halt or Reverse Subsidence on Public Lands

For all publicly-owned lands in the Delta or Suisun Marsh, State and local agencies should develop or update plans that identify land management goals; identify appropriate public or private uses for that property; and describe the operation and maintenance requirements needed to implement management goals. These plans should address subsidence and consider the feasibility of subsidence reversal.

Core Strategy 4: Protect Native Species and Reduce the Impact~~Prevent Introduction~~ of ~~and Manage~~ Nonnative Invasive Species ~~Impacts~~

While large-scale ecosystem restoration is the priority approach to support native species recovery, some stressors require more focused interventions. In particular, management actions continue to be necessary to avoid introductions of, and reduce the spread of, non-native invasive species. In managing native fish populations, reestablishing riparian habitat and in-stream connectivity along migratory corridors supports the reproductive success and survival of native fish. Hatcheries and harvest regulation should employ adaptive management strategies to predict and evaluate outcomes and minimize risks.

Prevent Introduction of Nonnative Species and Manage Nonnative Species Impacts

Problem Statement

Nonnative **invasive** species are **both a symptom of a highly degraded ecosystem and** a major obstacle to successful restoration of the Delta ecosystem because they **can** affect the survival, health, and distribution of native Delta **plants and** wildlife~~ and plants~~. **Native species are impacted by nonnative invasive species through competition, predation, disease and other interactions. The establishment of new nonnative invasive species is likely within the highly altered landscape of the Delta and could result in further ecosystem effects.** ~~There is little chance of eradicating most established nonnative species, but management can reduce the abundance of some.~~ **Native species are also impacted**~~ The resilience of native species is reduced~~ by ongoing **activities**~~introductions of nonnative species and management actions~~ that **improve habitat**~~enhance~~ conditions for **existing** nonnative **invasive** species.

Policy

ER P5. Avoid Introductions of and Habitat Improvements for Invasive Nonnative Species

(a) *The potential for new introductions of or improved habitat conditions for nonnative invasive species, striped bass, or bass must be fully considered and avoided or mitigated in a way that appropriately protects the ecosystem.*

(b) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that has the reasonable probability of introducing or improving habitat conditions for nonnative invasive species.*

Recommendations

~~**ER R6. Regulate Angling for Nonnative Sport Fish to Protect Native Fish**~~

~~*The California Department of Fish and Wildlife should develop, for consideration by the Fish and Game Commission, proposals for new or revised fishing regulations designed to increase populations of listed fish species through reduced predation by introduced sport fish. The proposals should be based on sound science that demonstrates these management actions are likely to achieve their intended outcome and include the development of performance measures and a monitoring plan to support adaptive management.*~~

ER R7. Prioritize and Implement Actions to Control Nonnative Invasive Species

The ***Delta Conservancy, Delta Science Program,*** *California Department of Fish and Wildlife****, California Department of Food and Agriculture, California Department of Parks and Recreation, Division of Boating and Waterways,*** *and other **State and federal**~~appropriate~~ agencies should **develop**~~prioritize~~ and ~~fully~~ implement **communication and funding strategies to manage existing nonnative invasive species and for rapid response to new introductions of nonnative invasive species, based on scientific expertise and research**~~the list of "Stage 2 Actions for Nonnative Invasive Species" and accompanying text shown in Appendix J taken from the Conservation Strategy for Restoration of the Sacramento–San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions (DFG 2011). Implementation of the Stage 2 actions should include the development of performance measures and monitoring plans to support adaptive management~~.*

~~Core Strategy 5: Improve Hatcheries and Harvest Management~~

Improve Fish Management

Problem Statement

Fish migration is impaired by barriers and unscreened diversions within and upstream of the Delta, and these impacts will be compounded with a rapidly changing climate. Aquatic habitat conditions within the Delta support nonnative, predatory fish species, further reducing native fish survival. Hatcheries and harvest regulation are important tools in fisheries management, but they also pose genetic and ecological risks to **wild salmon runs, other** native species**,** and the Delta ecosystem. These practices need to employ adaptive management strategies to predict and evaluate outcomes~~,~~ and minimize risks.

Recommendations

New ER Recommendation "H." Prioritize Unscreened Diversions within the Delta

The California Department of Fish and Wildlife should collect field data to inform prioritization of unscreened diversions within the Delta.

New ER Recommendation "I". Fund Projects to Improve Survival of Juvenile Salmon

Public agencies should fund and implement projects that improve aquatic habitat conditions and reduce predation risk for juvenile salmon along the priority migration corridors identified in Chapter 4, Figure 4-~~7~~8. Projects that could improve survival of juvenile salmon include levee setbacks and waterside habitat improvements, placement of fish guidance structures, and nonnative aquatic weed management.

ER R8. Manage Hatcheries to Reduce ~~Genetic~~ Risk of Adverse Effects

*~~As required by the National Marine Fisheries Service,~~ **A**~~a~~ll **public agencies that manage** hatcheries **potentially affecting**~~providing~~ listed fish **species**~~for release into the wild~~ should **develop, or** continue to develop**, periodically update,** and*

implement scientifically sound Hatchery and Genetic Management Plans (HGMPs) to reduce risks to ***Central Valley natural-origin and listed****~~those~~ species.~~ The California Department of Fish and Wildlife should provide annual updates to the Delta Stewardship Council on the status of HGMPs within its jurisdiction.~~*

ER R9. Coordinate Fish Migration and Survival Research~~Implement Marking and Tagging Program~~

*~~By December 2014, ~~**T**~~t~~he California Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, should* ***seek coordination among researchers studying juvenile anadromous fish migration pathways and survival upstream of, and within the Delta waterways to improve synthesis of results across research efforts and application to adaptive management actions.****~~revise and begin implementing its program for marking and tagging hatchery salmon and steelhead to improve management of hatchery and wild stocks based on recommendations of the California Hatchery Scientific Review Group, which considered mass marking, reducing hatchery programs, and mark selective fisheries in developing its recommendations.~~*

Core Strategy 5: Improve Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement

A large and diverse array of public agencies and private organizations are engaged in ecosystem protection, enhancement, restoration, and mitigation in the Delta, with roles ranging from regulatory oversight to project implementation and long-term monitoring and management. Improving the efficiency and effectiveness of these efforts will require institutional commitment to a single, consolidated restoration forum with agency support and discretion to guide restoration strategies, plan investments, align individual agency plans and actions, and resolve barriers to implementation.

Increase Interagency Coordination and Support for Restoration Projects

Problem Statement

Broad, landscape scale changes are necessary to restore ecosystem functions in the Delta and Suisun Marsh. While coordination between State, federal and local agencies on ecosystem restoration has dramatically improved through forums such as the Delta Plan Interagency Implementation Committee and the Interagency Adaptive Management and Integration Team, slow progress in protecting and restoring the Delta ecosystem reveals an ongoing need to better coordinate plans and actions that contribute to ecosystem restoration.

Recommendations

New ER Recommendation "F". Support Implementation of Ecosystem Restoration

Local, State and federal agencies should coordinate to support implementation of ecosystem restoration, and the Delta Plan Interagency Implementation Committee (DPIIC) should:

- ***(a) Consider establishing an ecosystem restoration subcommittee.***
- ***(b) Develop strategies for acquisition and long-term ownership and management of lands necessary to achieve ecosystem restoration consistent with the guidance in Appendix Q2.***
- ***(c) Develop a funding strategy that identifies a portfolio of approaches to remove institutional barriers and fund Ecosystem Restoration Tier 1 or 2 actions within the Delta.***
- ***(d) Establish program-level endangered species permitting mechanisms that increase efficiency for Ecosystem Restoration Tier 1 or 2 actions within the Delta and compatible ecosystem restoration projects within the Delta watershed.***
- ***(e) Coordinate with the Delta Science Program to align State, federal, and local resources for scientific support of restoration efforts, including adaptive management, data tools, monitoring, synthesis, and communication.***
- ***(f) Develop a landscape-scale strategy for recreational access to existing and future restoration sites, where appropriate and while maintaining ecological value.***

New ER Recommendation "G". Align State Restoration Plans and Conservation Strategies with the Delta Plan

- ***Agencies should coordinate, and the Delta Plan Interagency Implementation Committee (DPIIC) should consider establishing a subcommittee, to align State, local, or regional restoration strategies, plans or programs in the Delta to be consistent with the priority attributes described in Appendix Q2. These include:***
  - ***(a) The Delta Conservation Framework;***
  - ***(b) The CVFPP Conservation Strategy;***
  - ***(c) The Public Lands Strategy;***
  - ***(d) Regional Conservation Investment Strategies;***
  - ***(e) Regional Conservation Strategies or Partnerships; and.***
  - ***(f) San Francisco Bay and Suisun Marsh Conservation Strategies, Investments and Partnerships, as appropriate.***

Attachment C-2
Regulatory Appendices

Appendix C
Attachment C-2.1
Proposed Regulatory Requirements to Demonstrate Consistency with Regulatory Policies and New Definitions.
Appendix 3A: ER PA, Appendix 4A: ER P2, and New Proposed Definitions Related to Appendix 3A and 4A

DRAFT

Regulatory Requirements to Demonstrate Consistency with Regulatory Policies and New Definitions

APPENDIX 3A: ER PA (23 CCR Section [TBD])

APPENDIX 4A: ER P2 (23 CCR Section 5006)

DEFINITIONS: New proposed definitions related to Appendix 3A and 4A (23 CCR Section 5001)

Delta Plan Amendments

May 2020

For assistance interpreting the content of this document, please contact Delta Stewardship Council staff.

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Contents

Tables

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Appendix 3A. Disclosing Contributions to Restoring Ecosystem Function and Providing Social Benefits (23 CCR [TBD])

A certification of consistency for any covered action that is subject to New Ecosystem Restoration (ER) Policy "A" must include a completed Appendix 3A, as well as the documentation and information required by Appendix 3A.

Section 1. Priority Attributes and Ecosystem Tier

Priority Attributes

Appendix 3A, Section 1, Subsections 1.1 through 1.5 (Priority Attributes) require the selection of criteria and the disclosure of supporting information to identify whether the covered action would have any of the following five priority attributes (a covered action may have more than one priority attribute):

1.1 Restoring Hydrological, Geomorphic, and Biological Processes

1.2 Being Large-Scale

1.3 Improving Connectivity

1.4 Increasing Native Vegetation Cover

1.5 Contributing to the Recovery of Special-Status Species

Appendix 3A, Section 1, Subsection 1.6 (Ecosystem Restoration Tier) requires the identification of the appropriate Ecosystem Restoration Tier for the covered action, based on the selections in Subsections 1.1 through 1.5 of Section 1.

Restoring Hydrological, Geomorphic, and Biological Processes

1.1.1 In **Field 1** of **Table 1-1** below, select the ecosystem type(s) that the covered action proposes to restore, if any. Select <u>all</u> that apply.

1.1.2 In **Field 2** of **Table 1-1** below, select the corresponding hydrological, geomorphic, and/or biological process(es) that the covered action proposes to restore, if any. Select <u>all</u> that apply.

Table 1-1. Priority Attribute 1 – Restoring Hydrological, Geomorphic, and Biological Processes Selections

Row Number	Field 1. Ecosystem Type	Field 2. Hydrological, Geomorphic, and Biological Processes
1	☐ Tidal wetland	☐ Full tidal action and complex variable patterns of tidal inundation ☐ Sediment delivery, scour, and accretion ☐ Channel formation ☐ Delivery of organic and nonorganic compounds which support nutrient cycling, primary productivity, plant growth, and peat formation ☐ Native vegetation recruitment, growth and succession, primary production, and higher trophic-level interactions
2	☐ Nontidal wetland	☐ Temporary or permanent inundation through natural hydrologic connections to surface and/or groundwater, but does not include managed wetlands ☐ Hydric soil development through organic matter accumulation and/or terrestrial sediment delivery ☐ Delivery of organic and nonorganic compounds which support nutrient cycling, primary productivity, plant growth, and peat formation ☐ Native vegetation recruitment, growth, succession, primary production, and higher trophic-level interactions
3	☐ Willow thicket	☐ Temporary or seasonal floodplain inundation ☐ Floodplain sediment delivery, scour, and accretion which results in complex floodplain micro-topography ☐ Unrestrained (natural) stream channels which allow cut-bank and point-bar formation, meander migration, and the development of shaded riverine aquatic habitats ☐ Delivery of organic and nonorganic compounds which support nutrient cycling, primary productivity, plant growth, and floodplain soils ☐ Native vegetation recruitment, growth, succession, primary production, and higher trophic-level interactions
4	☐ Willow riparian scrub or shrub	☐ Temporary or seasonal floodplain inundation ☐ Floodplain sediment delivery, scour, and accretion which results in complex floodplain micro-topography ☐ Unrestrained (natural) stream channels which allow cut-bank and point-bar formation, meander migration, and the development of shaded riverine aquatic habitats ☐ Delivery of organic and nonorganic compounds which support nutrient cycling, primary productivity, plant growth, and floodplain soils ☐ Native vegetation recruitment, growth, succession, primary production, and higher trophic-level interactions

Table 1-1. Priority Attribute 1 – Restoring Hydrological, Geomorphic, and Biological Processes Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Hydrological, Geomorphic, and Biological Processes
5	☐ Valley foothill riparian	☐ Temporary or seasonal floodplain inundation ☐ Floodplain sediment delivery, scour, and accretion which results in complex floodplain micro-topography ☐ Unrestrained (natural) stream channels which allow cut-bank and point-bar formation, meander migration, and the development of shaded riverine aquatic habitats ☐ Delivery of organic and nonorganic compounds which support nutrient cycling, primary productivity, plant growth, and floodplain soils ☐ Native vegetation recruitment, growth, succession, primary production, and higher trophic-level interactions
6	☐ Vernal pool complex	☐ Water inputs from precipitation, runoff, groundwater or subsurface flow that cause temporary inundation and saturation with water ☐ Morphology (surface area, volume, depth, depth to hardpan) which supports hydrology, chemical processes, and native species colonization and persistence ☐ Hydrology and hydrogeomorphic setting that supports appropriate wetland soil development ☐ Native vegetation recruitment, growth, succession, primary production, higher trophic-level interactions, and appropriate pool substrates
7	☐ Alkali seasonal wetland complex	☐ Water inputs from precipitation, runoff, groundwater or subsurface flow that cause temporary inundation and saturation with water ☐ Morphology (surface area, volume, depth, depth to hardpan) which supports hydrology, chemical processes, and native species colonization and persistence ☐ Hydrology and hydrogeomorphic setting that supports appropriate wetland soil development ☐ Native vegetation recruitment, growth, succession, primary production, higher trophic-level interactions, and appropriate pool substrates

Table 1-1. Priority Attribute 1 – Restoring Hydrological, Geomorphic, and Biological Processes Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Hydrological, Geomorphic, and Biological Processes
8	☐ Wet meadow	☐ Water inputs from precipitation, runoff, groundwater or subsurface flow that cause temporary inundation and saturation with water ☐ Morphology (surface area, volume, depth, depth to hardpan) which supports hydrology, chemical processes, and native species colonization and persistence ☐ Hydrology and hydrogeomorphic setting that supports appropriate wetland soil development ☐ Native vegetation recruitment, growth, succession, primary production, higher trophic-level interactions, and appropriate pool substrates
9	☐ Stabilized interior dune vegetation	☐ Readily draining substrates ☐ Wind-driven geomorphic processes ☐ Movement, scour, and deposition which supports recruitment, growth, and succession of native dune scrub vegetation communities
10	☐ Oak woodland	☐ Fire disturbance or fire disturbance analogue (e.g., grazing) which maintains vegetation dynamics conducive to oak recruitment and other vegetation dynamics
11	☐ Grassland	☐ Fire disturbance or fire disturbance analogue (e.g., grazing) which maintains vegetation dynamics conducive to oak recruitment and other vegetation dynamics

1.1.3 In **Table 1-1**, above, each row in **Field 1** lists an ecosystem type, and in the same row in **Field 2** are the corresponding hydrological, geomorphic, and biological processes that a covered action could restore.

Based on the ecosystem type(s) selected in **Field 1**, would the proposed action restore any corresponding hydrological, geomorphic, and biological processes in **Field 2**?

○ Yes

○ No (continue to Section 1.2)

1.1.4 If the answer to **Section 1.1.3** is "Yes," describe how the proposed action would restore the selected hydrological, geomorphic, and biological process(es) selected in **Table 1-1** above, and attach supporting documentation.

Being Large-Scale

1.2.1 In **Field 1** of **Table 1-2** below, select the ecosystem type(s) that the covered action proposes to restore. Select all that apply.

1.2.2 In **Field 2** of **Table 1-2** below, select the corresponding area where the covered action proposes to restore hydrological, geomorphic, and biological processes. For every row that is selected in **Field 1**, make a corresponding selection in **Field 2**.

Table 1-2. Priority Attribute 2 – Being Large-Scale Selections

Row Number	Field 1. Ecosystem Type	Field 2. Proposed Restored Area
1	☐ Tidal wetland	☐ > or = 500 acres (large-scale) ☐ < 500 acres
2	☐ Nontidal wetland (including managed wetland)	☐ > or = 500 acres (large-scale) ☐ < 500 acres
3	☐ Willow thicket	☐ > or = 200 acres (large-scale) ☐ < 200 acres ☐ Floodplain ratio[1] > or = 6 (large-scale) *refer to table notes for methodology* ☐ Floodplain ratio[1] < 6
4	☐ Willow riparian scrub or shrub	☐ > or = 200 acres (large-scale) ☐ < 200 acres ☐ Floodplain ratio[1] > or = 6 (large-scale) *refer to table notes for methodology* ☐ Floodplain ratio[1] < 6
5	☐ Valley foothill riparian	☐ > or = 200 acres (large-scale) ☐ < 200 acres ☐ Floodplain ratio[1] > or = 6 (large-scale) *refer to table notes for methodology* ☐ Floodplain ratio[1] < 6
6	☐ Vernal pool complex	☐ > or = 40 acres (large-scale) ☐ < 40 acres
7	☐ Alkali seasonal wetland complex	☐ > or = 40 acres (large-scale) ☐ < 40 acres
8	☐ Wet meadow	☐ > or = 40 acres (large-scale) ☐ < 40 acres
9	☐ Stabilized interior dune vegetation	☐ > or = 1.5 acres (large-scale) ☐ < 1.5 acres

Table 1-2. Priority Attribute 2 – Being Large-Scale Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Proposed Restored Area
10	☐ Oak woodland	☐ > or = 40 acres (large-scale) ☐ < 40 acres
11	☐ Grassland	☐ > or = 40 acres (large-scale) ☐ < 40 acres

Notes:
[1] Method to calculate the floodplain ratio
a. Existing bankfull channel width (use the mean of at least six cross sections): ________ meters
b. Protected, restored, or enhanced floodplain width: ________ meters
c. Floodplain ratio (divide [b] by [a])

1.2.3 In **Table 1-2**, above, each row in **Field 1** lists an ecosystem type(s), and the corresponding row in **Field 2** lists the restoration area that would be considered large-scale.

Based on the selection(s) made in **Field 2**, would any selected restoration area for the covered action be large-scale?

○ Yes

○ No (continue to Section 1.3)

1.2.4 If the answer to **Section 1.2.3** is “Yes,” describe the area of each ecosystem type that the covered action proposes to restore, corresponding to the selections in **Table 1-2** above, and attach supporting documentation.

Improving Connectivity

1.3.1 In **Field 1** of **Table 1-3** below, select the aspect(s) of connectivity that the covered action proposes to improve. Select all that apply.

Table 1-3. Priority Attribute 3 – Improving Connectivity Selections

Row Number	Field 1. Aspects of Connectivity
1	☐ Creates or reestablishes hydraulic and hydrologic connections to marsh or floodplain ecosystems
2	☐ Reduces distance between patches of similar ecosystem types
3	☐ Reduces distance between patches of different ecosystem types used by species for refuge or life history needs
4	☐ Protects, restores, or enhances wetland and riparian transgression/migration space
5	☐ Removes or remediates barriers (dams and diversions) to fish migration

1.3.2 Selecting at least one Aspect of Connectivity in **Table 1-3** above indicates that the proposed action would improve connectivity. Based on the selection(s) in **Table 1-3**, would the covered action improve connectivity?

◯ Yes
◯ No (continue to Section 1.4)

1.3.3 If the answer to **Section 1.3.2** is "Yes," describe how the covered action would improve the aspect(s) of connectivity selected in **Field 1** of **Table 1-3** above, and attach supporting documentation.

Increasing Native Vegetation Cover

1.4.1 In **Field 1** of **Table 1-4** below, select the ecosystem type(s) that the covered action proposes to restore. Select all that apply.

1.4.2 In **Field 2** of **Table 1-4** below, select the corresponding native vegetation community or communities for which the covered action would increase cover. Select all that apply.

Table 1-4. Priority Attribute 4 – Increasing Native Vegetation Cover Selections

Row Number	Field 1. Ecosystem Type	Field 2. Native Vegetation Community (VegCAMP CaCode)
1	☐ Tidal wetland	☐ *Schoenoplectus* (*acutus*, *californicus*) Alliance (52.128.00) ☐ *Typha* (*domingensis*, *latifolia*) Alliance (52.050.00) ☐ *Juncus effuses* (soft rush marshes) Alliance (45.561.00) ☐ *Juncus articus* (Baltic and Mexican rush marshes) Alliance (45.562.00) ☐ *Eleocharis macrostachya* Alliance (45.230.00) ☐ *Sarcocornia pacifica* Alliance (52.215.00) ☐ *Distichlis spicata* Alliance (41.200.00) ☐ Other
2	☐ Nontidal wetland (including managed wetland)	☐ *Schoenoplectus* (*acutus*, *californicus*) Alliance (52.128.00) ☐ *Typha* (*domingensis*, *latifolia*) Alliance (52.050.00) ☐ *Juncus effuses* (soft rush marshes) Alliance (45.561.00) ☐ *Juncus articus* (Baltic and Mexican rush marshes) Alliance (45.562.00) ☐ *Eleocharis macrostachya* Alliance (45.230.00) ☐ Other
3	☐ Willow thicket	☐ *Salix gooddingii* Alliance (61.211.00) ☐ *Salix laevigata* Alliance (61.206.00) ☐ *Salix lasiolepus* Alliance (61.201.00) ☐ *Salix lucida* Alliance (61.204.00) ☐ *Salix exigua* Alliance (61.209.00) ☐ *Cornus sericea* (red osier thickets) Alliance (80.100.00) ☐ *Rosa californica* Alliance (63.907.00) ☐ *Acer negundo* (box-elder forest) Alliance (61.440.00) ☐ *Sambucus nigra* (blue elderberry stands) Alliance (63.410.01) ☐ Other

Table 1-4. Priority Attribute 4 – Increasing Native Vegetation Cover Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Native Vegetation Community (VegCAMP CaCode)
4	☐ Willow riparian scrub or shrub	☐ *Salix gooddingii* Alliance (61.211.00) ☐ *Salix laevigata* Alliance (61.206.00) ☐ *Salix lasiolepus* Alliance (61.201.00) ☐ *Salix lucida* Alliance (61.204.00) ☐ *Salix exigua* Alliance (61.209.00) ☐ *Cornus sericea* (red osier thickets) Alliance (80.100.00) ☐ *Rosa californica* Alliance (63.907.00) ☐ *Acer negundo* (box-elder forest) Alliance (61.440.00) ☐ *Cephalanthus occidentalis* (button willow thickets) Alliance (63.300.00) ☐ Other
5	☐ Valley foothill riparian	☐ *Quercus agrifolia* Alliance (71.060.00) ☐ *Quercus lobata* Alliance (71.040.00) ☐ *Quercus (agrifolia*, *douglasii, garryana, kelloggii, lobata, wislizeni*) Alliance (71.100.00) ☐ *Quercus wislizeni* Alliance (71.080.00) ☐ *Juglans hindsii* and hybrids special stands Alliance (61.810.00) ☐ *Salix gooddingii* Alliance (61.211.00) ☐ *Salix laevigata* Alliance (61.205.00) ☐ *Salix lasiolepis* Alliance (61.201.00) ☐ *Salix lucida* Alliance (61.204.00) ☐ *Salix exigua* Alliance (61.209.00) ☐ *Acer negundo* (box-elder forest) Alliance (61.440.00) ☐ *Cornus sericea* (red osier thickets) Alliance (80.100.00) ☐ *Rosa californica* Alliance (63.907.00) ☐ *Platanus racemosa* Alliance (61.310.00) ☐ *Populus fremontii* Alliance (61.130.00) ☐ *Cephalanthus occidentalis* (button willow thickets) Alliance (63.300.00) ☐ Other
6	☐ Vernal pool complex	☐ *Lasthenia fremontii – Downingia bicornuta* (Fremont's goldfields – *Downingia* vernal pools) Alliance (42.007.00) ☐ *Eryngium aristulatum* Alliance (42.004.00) ☐ Other

Table 1-4. Priority Attribute 4 – Increasing Native Vegetation Cover Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Native Vegetation Community (VegCAMP CaCode)
7	☐ Alkali seasonal wetland complex	☐ *Cressa truxillensis – Distichlis spicata* (alkali weed - saltgrass playas and sinks) Alliance (46.100.00) ☐ *Lasthenia fremontii – Distichlis spicata* (Fremont's goldfields – saltgrass alkaline vernal pools) Alliance (44.119.00) ☐ *Allenrolfea occidentalis* (iodine bush scrub) Alliance (36.120.00) ☐ *Sporobolus airoides* (alkali sacaton grassland) Alliance (52.060.00) ☐ *Leymus cinereus – Leymus triticoides* (creeping rye grass turfs) Alliance (41.080.00) ☐ *Frankenia salina* (alkali heath marsh) Alliance (52.500.00) ☐ Other
8	☐ Wet meadow	☐ *Lasthenia californica – Plantago erecta – Vulpia microstachys* (California goldfields – dwarf plantain – six-weeks fescue flower fields) Alliance (44.108.00) ☐ *Leymus cinereus – Leymus triticoides* (creeping rye grass turfs) Alliance (41.080.00) ☐ *Ambrosia psilostachya* (western ragweed meadows) Alliance (33.065.00) ☐ *Lotus purshianus* (Spanish clover fields) Provisional Herbaceous Alliance (52.230.00) ☐ *Juncus effusus* (soft rush marshes) Alliance (45.561.00) ☐ *Juncus articus* (Baltic and Mexican rush marshes) Alliance (45.562.00) ☐ Other
9	☐ Stabilized interior dune vegetation	☐ *Lupinus albifrons* (silver bush lupine scrub) Alliance (32.081.00) ☐ *Baccharis pilularis* (coyote brush scrub) Alliance (32.060.00) ☐ *Lotus scoparius* (deer weed scrub) Alliance (52.240.00) ☐ Other
10	☐ Oak woodland	☐ *Quercus agrifolia Alliance (71.060.00)* ☐ *Quercus lobata Alliance (71.040.00)* ☐ *Quercus (agrifolia, douglasii, garryana, kelloggii, lobata, wislizeni) Alliance (71.100.00)* ☐ *Quercus wislizeni Alliance (71.080.00)* ☐ *Quercus douglasii Alliance (71.020.00)* ☐ Other

Table 1-4. Priority Attribute 4 – Increasing Native Vegetation Cover Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Native Vegetation Community (VegCAMP CaCode)
11	☐ Grassland	☐ *Lasthenia californica – Plantago erecta – Vulpia microstachys* (California goldfields – Dwarf plantain – six-weeks fescue flower fields) Alliance (44.108.00) ☐ *Leymus cinereus – Leymus triticoides* (creeping rye grass turfs) Alliance (41.080.00) ☐ *Nassella pulchra* Alliance (41.150.00) ☐ *Eschscholzia californica* (California poppy fields) Alliance (43.200.00) ☐ *Amsinckia* (fiddleneck fields) Alliance (42.110.00) ☐ *Plagiobothrys nothofulvus* (popcorn flower fields) Alliance (43.300.00) ☐ Other

Note:
VegCAMP is the California component of the National Vegetation Classification system, maintained by the California Department of Fish and Wildlife in collaboration with other agencies and organizations.

1.4.3 Refer to both **Table 1-2** and **Table 1-4** for this section. On what share of the aggregate area(s) selected in **Field 2** of **Table 1-2** would the covered action increase the cover of the native vegetation community or communities selected in **Field 2** of **Table 1-4**?

- ◯ At least 75% of the aggregate area (increases native vegetation cover)
- ◯ Less than 75% of the aggregate area

1.4.4 Based on the selection in **Section 1.4.3** above, would the covered action increase native vegetation cover?

- ◯ Yes
- ◯ No (continue to Section 1.5)

1.4.5 Describe how the covered action would increase cover of the native vegetation communities selected in **Table 1-4**, across the area selected in **Section 1.4.3**, and attach supporting documentation. If the selection(s) in Table 1-4 include "Other," identify and describe those native vegetation communities here.

Contributing to the Recovery of Special-Status Species

1.5.1 In **Field 1** of **Table 1-5** below, select the ecosystem type(s) that the covered action proposes to restore. Select all that apply.

1.5.2 In **Field 2** of **Table 1-5** below, select the corresponding special-status species whose recovery would be contributed to by the proposed action. Select all that apply.

Table 1-5. Priority Attribute 5 – Contributing to the Recovery of Special-Status Species Selections

Row Number	Field 1. Ecosystem Type	Field 2. Special-Status Species
1	☐ Tidal wetland	☐ California least tern (*Sterna antillarum browni*) ☐ Ridgway's rail (*Rallus obsoletus*) ☐ California black rail (*Laterallus jamaicensis coturniculus*) ☐ Suisun song sparrow (*Melospiza melodia*) ☐ Tricolored blackbird (*Agelaius tricolor*) ☐ White-tailed kite (*Elanus leucurus*) ☐ Salt marsh harvest mouse (*Reithrodontomys raviventris*) ☐ Suisun shrew (Sorex ornatus sinuosus) ☐ California red-legged frog (*Rana draytonii*) ☐ Western pond turtle (*Actinemys marmorata*) ☐ Giant garter snake (*Thamnophis gigas*) ☐ Green sturgeon (*Acipenser medirostris*) ☐ Delta smelt (*Hypomesus transpacificus*) ☐ Longfin smelt (*Spirinchus thaleichthys*) ☐ Chinook salmon (Central Valley fall/late fall-run) (*Oncorhynchus tshawytscha*) ☐ Chinook salmon (Central Valley spring-run) (*Oncorhynchus tshawytscha*) ☐ Chinook salmon (Sacramento River winter-run) (*Oncorhynchus tshawytscha*) ☐ Steelhead (*Oncorhynchus mykiss*) ☐ Delta mudwort (*Limosella subulata*) ☐ Mason's lilaeopsis (*Lilaeopsis masonii*) ☐ Slough thistle (*Cirsium crassicaule*) ☐ Delta tule pea (*Lathyrus jepsonii*) ☐ Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*) ☐ Suisun marsh aster (*Symphyotrichum lentum*) ☐ Soft bird's beak (*Choropyron molle* ssp. *molle*) ☐ Side flowering skullcap (*Scutellaria lateriflora*) ☐ Other special-status species

Table 1-5. Priority Attribute 5 – Contributing to the Recovery of Special-Status Species Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Special-Status Species
2	☐ Nontidal wetland (including managed wetland)	☐ California least tern (*Sterna antillarum browni*) ☐ Ridgway's rail (*Rallus obsoletus*) ☐ California black rail (*Laterallus jamaicensis coturniculus*) ☐ Suisun song sparrow (*Melospiza melodia*) ☐ Tricolored blackbird (*Agelaius tricolor*) ☐ White-tailed kite (*Elanus leucurus*) ☐ Salt marsh harvest mouse (*Reithrodontomys raviventris*) ☐ Suisun shrew (*Sorex ornatus sinuosus*) ☐ California red-legged frog (*Rana draytonii*) ☐ Western pond turtle (*Actinemys marmorata*) ☐ Giant garter snake (*Thamnophis gigas*) ☐ Delta mudwort (*Limosella subulata*) ☐ Mason's lilaeopsis (*Lilaeopsis masonii*) ☐ Slough thistle (*Cirsium crassicaule*) ☐ Delta tule pea (*Lathyrus jepsonii*) ☐ Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*) ☐ Suisun marsh aster (*Symphyotrichum lentum*) ☐ Soft bird's beak (*Choropyron molle* ssp. *molle*) ☐ Side flowering skullcap (*Scutellaria lateriflora*) ☐ Other special-status species
3	☐ Willow thicket	☐ Least Bell's vireo (*Vireo bellii pusillus*) ☐ Western yellow-billed cuckoo (*Coccyzus americanus*) ☐ Yellow-breasted chat (*Icteria virens*) ☐ Swainson's hawk (*Buteo swainsoni*) ☐ San Joaquin kit fox (*Vulpes macrotis mutica*) ☐ Riparian woodrat (Neotoma fuscipes riparia) ☐ Riparian brush rabbit (*Sylvilagus bachmani*) ☐ Chinook salmon (Central Valley fall/late fall-run) (*Oncorhynchus tshawytscha*) ☐ Chinook salmon (Central Valley spring-run) (*Oncorhynchus tshawytscha*) ☐ Chinook salmon (Sacramento River winter-run) (*Oncorhynchus tshawytscha*) ☐ Steelhead (*Oncorhynchus mykiss*) ☐ Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) ☐ Other special-status species

Table 1-5. Priority Attribute 5 – Contributing to the Recovery of Special-Status Species Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Special-Status Species
4	☐ Willow riparian scrub or shrub	☐ Least Bell's vireo (*Vireo bellii pusillus*) ☐ Western yellow-billed cuckoo (*Coccyzus americanus*) ☐ Yellow-breasted chat (*Icteria virens*) ☐ Swainson's hawk (*Buteo swainsoni*) ☐ San Joaquin kit fox (*Vulpes macrotis mutica*) ☐ Riparian woodrat (*Neotoma fuscipes riparia*) ☐ Riparian brush rabbit (*Sylvilagus bachmani*) ☐ Chinook salmon (Central Valley fall/late fall-run) (*Oncorhynchus tshawytscha*) ☐ Chinook salmon (Central Valley spring-run) (*Oncorhynchus tshawytscha*) ☐ Chinook salmon (Sacramento River winter-run) (*Oncorhynchus tshawytscha*) ☐ Steelhead (*Oncorhynchus mykiss*) ☐ Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) ☐ Other special-status species
5	☐ Valley foothill riparian	☐ Least Bell's vireo (*Vireo bellii pusillus*) ☐ Western yellow-billed cuckoo (*Coccyzus americanus*) ☐ Yellow-breasted chat (*Icteria virens*) ☐ Swainson's hawk (*Buteo swainsoni*) ☐ San Joaquin kit fox (*Vulpes macrotis mutica*) ☐ Riparian woodrat (*Neotoma* fuscipes riparia) ☐ Riparian brush rabbit (*Sylvilagus bachmani*) ☐ Chinook salmon (Central Valley fall/late fall-run) (*Oncorhynchus tshawytscha*) ☐ Chinook salmon (Central Valley spring-run) (*Oncorhynchus tshawytscha*) ☐ Chinook salmon (Sacramento River winter-run) (*Oncorhynchus tshawytscha*) ☐ Steelhead (*Oncorhynchus mykiss*) ☐ Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) ☐ Other special-status species

Table 1-5. Priority Attribute 5 – Contributing to the Recovery of Special-Status Species Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Special-Status Species
6	☐ Vernal pool complex	☐ Greater sandhill crane (*Grus canadensis*) ☐ California red-legged frog (*Rana draytonii*) ☐ California tiger salamander (*Ambystoma californiense*) ☐ Giant garter snake (*Thamnophis gigas*) ☐ Vernal pool tadpole shrimp (*Lepidurus packardi*) ☐ Longhorn fairy shrimp (*Branchinecta longiantenna*) ☐ Vernal pool fairy shrimp (*Branchinecta lynchi*) ☐ Mid-valley fairy shrimp (*Branchinecta mesovallensis*) ☐ Conservancy fairy shrimp (*Branchinecta conservatio*) ☐ California linderiella (*Linderiella occidentalis*) ☐ Legenere (*Legenere limosa*) ☐ Boggs Lake hedge-hyssop (*Gratiola heterosepala*) ☐ Dwarf downingia (*Downingia pusilla*) ☐ Other special-status species
7	☐ Alkali seasonal wetland complex	☐ Greater sandhill crane (*Grus canadensis*) ☐ California red-legged frog (*Rana draytonii*) ☐ California tiger salamander (*Ambystoma californiense*) ☐ Giant garter snake (*Thamnophis gigas*) ☐ Vernal pool tadpole shrimp (*Lepidurus packardi*) ☐ Longhorn fairy shrimp (*Branchinecta longiantenna*) ☐ Vernal pool fairy shrimp (*Branchinecta lynchi*) ☐ Mid-valley fairy shrimp (*Branchinecta mesovallensis*) ☐ Conservancy fairy shrimp (*Branchinecta conservatio*) ☐ California linderiella (*Linderiella occidentalis*) ☐ Legenere (*Legenere limosa*) ☐ Boggs Lake hedge-hyssop (*Gratiola heterosepala*) ☐ Dwarf downingia (*Downingia pusilla*) ☐ Other special-status species
8	☐ Wet meadow	☐ Carquinez goldenbush (*Isocoma arguta*) ☐ Alkali milkvetch (*Astragalus tener*) ☐ Heckard's peppergrass (*Lepidium latipes* var. *heckardii*) ☐ Brittlescale (*Atriplex depressa*) ☐ Heartscale (*Atriplex cordulata* var. *cordulata*) ☐ Delta button celery (*Eryngium racemosum*) ☐ San Joaquin spearscale (*Atriplex joaquiniana*) ☐ Other special-status species

Table 1-5. Priority Attribute 5 – Contributing to the Recovery of Special-Status Species Selections (contd.)

Row Number	Field 1. Ecosystem Type	Field 2. Special-Status Species
9	☐ Stabilized interior dune vegetation	☐ Lange's metalmark butterfly (*Apodemia mormo langei*) ☐ Antioch Dunes evening primrose (*Oenothera deltoides howellii*) ☐ Contra Costa wallflower (*Erysimum capitatum*) ☐ Other special-status species
10	☐ Oak woodland	☐ Swainson's hawk (*Buteo swainsonii*) ☐ California red-legged frog (*Rana draytonii*) ☐ California tiger salamander (*Ambystoma califonriense*) ☐ Western pond turtle (*Actinemys marmorata*) ☐ Other special-status species
11	☐ Grassland	☐ Greater sandhill crane (*Grus canadensis*) ☐ White-tailed kite (*Elanus leucurus*) ☐ Yellow-breasted chat (*Icteria virens*) ☐ Swainson's hawk (*Buteo swainsonii*) ☐ Western burrowing owl (*Athene cunicularia*) ☐ California red-legged frog (*Rana draytonii*) ☐ California tiger salamander (*Ambystoma californiense*) ☐ Western pond turtle (*Actinemys marmorata*) ☐ Giant garter snake (*Thamnophis gigas*) ☐ Other special-status species

1.5.3 In **Table 1-5** above, each row in **Field 1** lists ecosystem type(s), and the corresponding row in Field 2 lists the special-status species for which a covered action could contribute to their recovery.

Based on the selection(s) made in **Field 2**, would the covered action contribute to the recovery of special-status species?

○ Yes

○ No (continue to Section 1.6)

1.5.4 If the answer to **Section 1.5.3** is "Yes," describe how the covered action would contribute to the recovery of the special-status species corresponding to the selections in **Table 1-5** above, and attach supporting documentation. If the selection(s) in Table 1-5 include "Other," identify and describe those special-status species in the area provided below.

Ecosystem Restoration Tier

1.6.1 **Field 1** of **Table 1-6.1,** below, lists Priority Attributes 1 through 5. The corresponding row in **Field 2** of **Table 1-6.1** lists the selection in this **Appendix 3A** made in Sections 1.1 through 1.5, above, on whether the covered action would have the applicable Priority Attribute.

Complete **Field 3** of **Table 1-6.1**, by copying the responses from the corresponding sections in Sections 1.1. through 1.5 of this **Appendix 3A** form, as indicated in **Field 2**.

Table 1-6.1. Summary of Responses

Row Number	Field 1. Priority Attribute	Field 2. Section Number	Field 3. Response to Section
1	Restoring Hydrological, Geomorphic, and Biological Processes	1.1.3	◯ Yes ◯ No
2	Being Large-Scale	1.2.3	◯ Yes ◯ No
3	Improving Connectivity	1.3.2	◯ Yes ◯ No
4	Increasing Native Vegetation	1.4.4	◯ Yes ◯ No
5	Contributing to the Recovery of Special-Status Species	1.5.3	◯ Yes ◯ No

1.6.2 Add the number of "Yes" responses in **Table 1-6.1** Field 3, and then select the corresponding number in **Field 1** of **Table 1-6.2**, below. The corresponding value in **Field 2** of **Table 1-6.2** is the covered action's ecosystem restoration tier.

Table 1-6.2. Calculated Ecosystem Restoration Tier

Row Number	Field 1. Number of "Yes" Responses in Table 1-6.1, Field 3, Rows 1 through 5	Field 2. Ecosystem Restoration Tier
1	☐ 1	☐ Tier 5
2	☐ 2	☐ Tier 4
3	☐ 3	☐ Tier 3
4	☐ 4	☐ Tier 2
5	☐ 5	☐ Tier 1

Section 2. Social Benefits and Delta as Place

Social Benefits

Appendix 3A, Section 2, Subsections 2.1 through 2.4 (Social Benefits) require the identification of the social benefits that would be provided by the covered action, and the disclosure of supporting information, in each of the following four categories:

2.1 Cultural Benefits

2.2 Recreational Benefits

2.3 Agricultural Benefits

2.4 Natural Resource Benefits

Cultural Benefits

2.1.1 In **Field 1** of **Table 2-1** below, select the types of cultural benefits that the covered action would provide. Select all that apply.

2.1.2 In **Field 2** of **Table 2-1** below, select the specific cultural benefits that the covered action would provide. Select all that apply.

Table 2-1. Cultural Benefits Selections

Row Number	Field 1. Types of Cultural Benefits	Field 2. Specific Cultural Benefits
1	☐ Ecocultural resources	☐ Supports long-term resilience of tribal ecocultural resource species ☐ Engages tribes in a way that respects sovereignty and protects or enhances access to natural resources ☐ Provides education on ecocultural resources through interpretive signage, facilities, or funding for interpretive personnel/events ☐ Supports responsible ecotourism, agritourism, sportfishing, hunting, or other cultural activities ☐ Involves the public in stewardship of ecocultural resources during project implementation or monitoring
2	☐ Human health and well-being	☐ Improves air quality, water quality, or environmental quality in a manner that is expected to protect or enhance human health and well-being ☐ Provides public access to lands for exercise, relaxation, and/or appreciation of natural beauty
3	☐ Environmental justice	☐ Redresses existing environmental inequities by targeting action and resources for disadvantaged and disproportionately impacted communities ☐ Engaged and co-planned with disadvantaged communities ☐ Improves access for safe subsistence fishing ☐ Improves environmental conditions (e.g., air quality or water quality) for at-risk groups

2.1.3 Based on the types of cultural benefits selected in **Field 1** of **Table 2-1**, and the specific cultural benefits selected in **Field 2,** would implementation of the covered action result in cultural benefits?

- ◯ Yes
- ◯ No

2.1.4 If the answer to **Section 2.1.3** is "Yes," describe how the covered action would provide the types of cultural benefits and specific cultural benefits selected in **Table 2-1**, and then attach supporting documentation. Cite any relevant literature or consultations with tribes, local communities, or experts.

2.1.5 If the answer to **Section 2.1.3** is "No," but the proposed action would provide cultural benefits not listed in the table above, describe the cultural benefits that the action would provide, and attach supporting documentation. Cite any relevant literature or consultations with tribes, local communities, or experts.

Recreational Benefits

2.2.1 In **Field 1** of **Table 2-2** below, select the specific recreational benefits that the covered action would provide. Select all that apply.

Table 2-2. Recreational Benefits Selections

Row Number	Field 1. Specific Recreational Benefits
1	☐ Provides opportunities for land-based recreational activities such as hiking and wildlife observation
2	☐ Provides opportunities for water-based recreational activities such as nonmotorized and motorized boating
3	☐ Connects users to the Great California Delta Trail System
4	☐ Includes public facilities such as restrooms
5	☐ Contributes to species populations in a way that benefits recreational fishing (e.g., salmon, sturgeon), nature study, and wildlife observation (e.g., birdwatching)
6	☐ Enhances public access to recreation (e.g., provides parking) while mitigating traffic impacts on neighboring agricultural and private lands

2.2.2 Based on the specific recreational benefits selected in **Field 1** of **Table 2-2**, would implementation of the covered action result in recreational benefits?

○ Yes

○ No

2.2.3 If the answer to **Section 2.2.2** is "Yes," describe how the covered action would provide the specific recreational benefits selected in **Table 2-2**, and then attach supporting documentation. Cite any relevant literature or consultations with local communities or experts.

2.2.4 If the answer to **Section 2.2.2** is "No," but the proposed action would provide recreational benefits not listed in the table above, describe the recreational benefits that the proposed action would provide, and attach supporting documentation. Cite any relevant literature or consultations with local communities or experts.

Agricultural Benefits

2.3.1 In **Field 1** of **Table 2-3** below, select the specific agricultural benefits that the covered action would provide. Select <u>all</u> that apply.

Table 2-3. Agricultural Benefits Selections

Row Number	Field 1. Specific Agricultural Benefits
1	☐ Protects or enhances ecological systems supportive of agriculture such as supporting pollination or natural pest control
2	☐ Conserves or improves soils in a manner that benefits agricultural land use
3	☐ Restores natural processes and communities that would reduce flood risk to neighboring agricultural lands
4	☐ Improves local water quality
5	☐ Recharges groundwater, increasing the water supply available in an aquifer, in locations that do not have high water tables
6	☐ Prevents increases in subsurface water levels, in locations with high water tables that interfere with agricultural activities

2.3.2 Based on the specific agricultural benefits selected in **Field 1** of **Table 2-3**, would implementation of the proposed action result in agricultural benefits?

○ Yes

○ No

2.3.3 If the answer to **Section 2.3.2** is "Yes," describe how the covered action would provide the specific agricultural benefits selected in **Table 2-3**, and then attach supporting documentation. Cite any relevant literature or consultations with local communities or experts.

2.3.4 If the answer to **Section 2.3.2** is "No," but the covered action would provide agricultural benefits not listed in the table above, describe the agricultural benefits that the action would provide, and attach supporting documentation. Cite any relevant literature or consultations with local communities or experts.

Natural Resource Benefits

2.4.1 In **Field 1** of **Table 2-4** below, select the specific natural resource benefits that the covered action would provide. Select all that apply.

Table 2-4. Natural Resource Benefits Selections

Row Number	Field 1. Specific Natural Resource Benefits
1	☐ Reduces flood risk by reducing peak water elevations
2	☐ Reduces flood risk by reducing operations and maintenance requirements on flood control works
3	☐ Reduces flood risk by reversing subsidence
4	☐ Reduces carbon emissions by reversing subsidence
5	☐ Mitigates climate change by sequestering carbon or other greenhouse gases
6	☐ Reduces heat island effects
7	☐ Increases native species habitat
8	☐ Enhances biodiversity of native species

2.4.2 Based on the specific natural resource benefits selected in **Field 1** of **Table 2-4**, would implementation of the covered action result in natural resource benefits?

- ◯ Yes
- ◯ No

2.4.3 If the answer to **Section 2.4.2** is "Yes," describe how the covered action would provide the specific natural resource benefits selected in **Table 2-4**, and then attach supporting documentation. Cite any relevant literature or consultations with local communities or experts.

2.4.4 If the answer to **Section 2.4.2** is "No," but the proposed action would provide natural resource benefits not listed in the table above, describe the natural resource benefits that the action would provide, and attach supporting documentation. Cite any relevant literature or consultations with local communities or experts.

Delta as Place

2.4.5 If the answers to **Section 2.1.3, Section 2.2.2**, **Section 2.3.2**, and **Section 2.4.2** are "No," explain how the proposed action would protect and enhance the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place (California Water Code section 85054), and then attach supporting documentation. Cite any relevant literature or consultations with local communities or experts.

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Appendix 4A. Protecting, Restoring, and Enhancing Habitats at Appropriate Elevations (23 CCR 5006)

A certification of consistency for any covered action that is subject to Section 5006 of Title 23 of the California Code of Regulations must include a completed Appendix 4A as well as the documentation and information required by Appendix 4A.

1.1.1 In **Field 1** of **Table 1-1** below, select the elevation band in which the project is located. If the project is located in more than one elevation band, select all applicable elevation bands.

1.1.2 In **Field 2** of **Table 1-1** below, select the type of conservation action that would be implemented by the project or a portion of the project. If more than one type of conservation action would be implemented by the project, or a portion of the project, select all applicable conservation actions.

Table 1-1. Elevation Bands and Conservation Actions

Row Number	Field 1. Elevation Bands	Field 2. Conservation Actions
1	☐ Upland elevation band	Protection, restoration, or enhancement of: ☐ Oak woodland ☐ Grassland ☐ Seasonal wetlands ☐ Upland and lowland river floodplain
2	☐ Floodplain elevation band	Protection, restoration, or enhancement of: ☐ Upland and lowland river floodplain ☐ Nontidal wetlands ☐ Annual flooding regimes ☐ Geomorphic processes
3	☐ Sea level rise accommodation band	Protection, restoration, or enhancement of: ☐ Oak woodland ☐ Grassland ☐ Seasonal wetlands ☐ Upland and lowland river floodplain ☐ Annual flooding regimes ☐ Geomorphic processes ☐ Emergent wetlands ☐ Migration space

Table 1-1. Elevation Bands and Conservation Actions (contd.)

Row Number	Field 1. Elevation Bands	Field 2. Conservation Actions
4	☐ Intertidal elevation band	Protection, restoration, or enhancement of: ☐ Tidal wetlands ☐ Tidal inundation regimes ☐ Migration space
5	☐ Shallow subtidal elevation band	☐ Subsidence halting[1] ☐ Subsidence reversal[1]
6	☐ Deep subtidal elevation band	☐ Subsidence halting[1] ☐ Subsidence reversal[1] ☐ Agricultural practices that support wildlife

Note:
[1] This is an outcome-based activity. Please see the regulatory definitions of *subsidence halting* and *subsidence reversal* in 23 CCR 5001. If this activity is selected, explain in Section 1.1.4 how the covered action would result in this outcome.

1.1.3 In **Table 1-1**, above, each row in **Field 1** lists the elevation band that is appropriate for the corresponding conservation actions listed in the same row in **Field 2**.

Based on the selected elevation band(s) in **Field 1** and the selected corresponding appropriate conservation action(s) in **Field 2**, is (are) the proposed conservation action(s) selected in **Field 2** appropriate for the selected elevation band(s) selected in **Field 1**? Do not select "Yes" if there is no selection in **Field 2** corresponding to each selected elevation band in **Field 1**.

○ Yes

○ No

1.1.4 If the answer to **Section 1.1.3** is "Yes," provide supporting evidence to demonstrate that the selections are accurate and describe such evidence below.

1.1.5 If the answer to **Section 1.1.3** is "No," based on best available science, provide a rationale for the inconsistency and explain how the conservation action is nonetheless at an appropriate elevation, and therefore consistent with this policy.

Definitions (23 CCR 5001)

The definitions set forth below would be codified in Section 5001 of Title 23 of the California Code of Regulations.

Agricultural Benefits: a category of social benefits that are derived by agricultural operations in the Delta, and the individuals and communities that those operations support. Agricultural benefits may include, but are not limited to, those listed in Table 2-3 in Appendix 3A.

Alkali Seasonal Wetland Complex: a type of seasonal wetland characterized by herbaceous or shrub communities and poorly drained, clay-rich soils with a high residual salt content.

Annual Flooding Regimes: river or stream flooding that occurs on an annual basis.

Aspects of Connectivity: an attribute of actions that restore ecosystem function, as defined in Table 1-3 in Appendix 3A.

Biological Processes: processes exhibited by the living components of an ecosystem such as nutrient cycling, primary production, vegetation and wildlife recruitment and growth, predation, and evolution.

Cultural Benefits: a category of social benefits that are derived by individuals and communities with distinct cultural ties to the ecosystems, plants, fish, and wildlife of the Delta. Cultural benefits may include, but are not limited to, those listed in Table 2-1 in Appendix 3A.

Deep Subtidal Elevation Band: In the Delta, land area that is located more than 8 feet below Mean Lower Low Water. In Suisun Marsh, land area that is located more than 4.5 feet below Mean Lower Low Water.

Disadvantaged Communities: as defined by Section 39711 of the California Health and Safety Code, means an area disproportionately affected by environmental pollution and other hazards that can lead to negative public health effects, exposure, or environmental degradation, or with concentrations of people that are of low income, high unemployment, low levels of homeownership, high rent burden, sensitive populations, or low levels of educational attainment.

Ecocultural Resources: resources needed to maintain the nature-dependent components of a culture in the face of externally driven social or natural change. Ecocultural resources may include, but are not limited to, those listed in Table 2-1 in Appendix 3A.

Emergent Vegetation: erect, nonwoody vegetation that grows in water but is rooted in sediment with stems and leaves that emerge out of the water; examples include, but are not limited to, bulrushes or cattails.

Emergent Wetland: wetland ecosystems with a plant community dominated by emergent vegetation; examples include tidal wetlands, nontidal wetlands, or managed wetlands.

Environmental Justice: as defined by Section 65040.12(e) of the California Government Code, the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.

Floodplain Elevation Band: lands above the Sea Level Rise Accommodation Band within the Yolo Bypass and the Lower Mokelumne-Cosumnes River and lower San Joaquin River corridors.

Geomorphic Processes: processes that shape and form the surface of the earth including erosion, deposition, river meander migration, and channel formation.

Grassland: a terrestrial ecosystem characterized by low nonwoody plant communities occupying well-drained soils, composed of native herbs and annual and perennial grasses, and usually devoid of trees.

Human Health and Well-Being: a condition of bodily comfort and happiness that is free from sickness or suffering, which can be derived from ecosystem processes, goods, and services, among other sources.

Hydrological Processes: processes exhibited by water, including streamflow, flooding, tidal action, percolation, and subsurface flow.

Intertidal Elevation Band: land area that is located between Mean Lower Low Water and Mean Higher High Water.

Inundation Regimes: the frequency and magnitude of flooding on the landscape.

Large-Scale: a type of covered action that restores hydrological, geomorphic, or biological processes on an area that is equal to or larger than the ecosystem-specific thresholds defined in Table 1-2 in Appendix 3A.

Managed Wetland: a type of wetland that requires human intervention to maintain wetland hydrology and vegetation. Human intervention includes, but is not limited to, actions such as construction of levees and berms, water management infrastructure, and vegetation management.

Migration Space: land that is located adjacent to, and at a higher elevation than, an existing ecosystem, which allows the ecosystem to gradually shift its location up in elevation in response to sea level rise.

Mean Higher High Water: A standard elevation defined by a certain phase of the tide that is used as a reference to measure local water levels. The average of the higher high water height of each tidal day observed over a period of time, typically across multiple years.

Mean Lower Low Water: A standard elevation defined by a certain phase of the tide that is used as a reference to measure local water levels. The average of the lower low water height of each tidal day observed over a period of time, typically across multiple years.

Mean Sea Level: A standard elevation defined by a certain phase of the tide that is used as a reference to measure local water levels. The arithmetic mean of hourly heights observed over a period of time, typically across multiple years.

Native Vegetation Community: a vegetation community with less than five percent cover comprised of nonnative plant species.

Natural Resource Benefits: a category of social benefits that are derived from an ecosystem, including processes, goods, and services. Natural resource benefits may include, but are not limited to, those listed in Table 2-4 in Appendix 3A.

Nonnative Invasive Species: species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat.

Nontidal wetland: a type of emergent wetland that is permanently saturated, dominated by emergent vegetation, and often occupying upstream floodplain positions above tidal influence. Distinct from seasonal wetlands, which are not permanently saturated.

Oak woodland: a terrestrial ecosystem characterized by sparse to dense oak-dominated tree communities with an understory of nonwoody plants such as grasses or herbs.

Recreational Benefits: a category of social benefits that are derived by individuals or groups that recreate in the Delta, and the business operations and communities that recreation supports, including but not limited to, those listed in Table 2-2 in Appendix 3A.

Saturated: in the context of the Delta Plan, a wet soil condition without standing water.

Sea Level Rise Accommodation Band: land area that is located between Mean Higher High Water and 10 feet above Mean Higher High Water.

Seasonal Wetland: seasonally saturated land with nonwoody plant communities; characterized by poorly drained, clay-rich soils; examples include vernal pool complex, alkali seasonal wetland complex, and wet meadow.

Shallow Subtidal Elevation Band: In the Delta, land area that is located between Mean Lower Low Water and 8 feet below Mean Lower Low Water. In Suisun Marsh, land area that is located between Mean Lower Low Water and 4.5 feet below Mean Lower Low Water.

Small-Scale: a type of covered action that restores hydrological, geomorphic, or biological processes on an area that is less than the ecosystem-specific thresholds defined in Table 1-2 in Appendix 3A. Not Large-Scale.

Social Benefits: positive effects that are derived by individuals, communities, or society at-large. In the context of Chapter 4 of the Delta Plan (Protect, Restore, and Enhance the Ecosystem), social benefits are the indirect cultural, recreational, agricultural, or natural resources benefits that individuals or groups of people derive from the protection, restoration, or enhancement of the ecosystem.

Special-Status Species: a species or subspecies of animal or plant, or a variety of a particular plant, that is endangered, rare, or threatened as defined by Section 15380 of Title 14 of the California Code of Regulations, or that is designated as a Species of Special Concern by the California Department of Fish and Wildlife.

Stabilized Interior Dune Vegetation: wind-driven sand deposits with vegetation dominated by shrub species, which may also support live oaks on more stabilized dunes that have more well-developed soil profiles.

Subsidence: Sinking of the land surface due to a number of factors, including groundwater extraction, agricultural activities, or oil or gas extraction. In the Delta, land subsidence is mainly caused by oxidation of peat soils, but also from wind erosion. Drainage and cultivation dry the saturated peat, reducing its volume by approximately 50 percent.

Subsidence Halting: a process that halts subsidence caused by organic soil oxidation in order to maintain land elevation. Subsidence halting results in land elevations that are nearly the same as land elevations prior to subsidence halting. Examples include, but are not limited to, managed inundation with water to halt oxidation through activities such as rice cultivation and managed wetlands.

Subsidence Reversal: a process that both halts subsidence caused by organic soil oxidation and leads to increases in land elevation through accumulation of new soil material. Subsidence reversal results in land elevations that are higher than land elevations prior to subsidence reversal; the process does not necessarily result in land elevations at or above mean sea level, as this depends on the initial elevation and the rate of subsidence reversal over time. Examples of subsidence reversal management actions include, but are not limited to, increasing land elevation by accreting organic material in managed wetlands, and placement of fill and levee breaching to reestablish hydrological connection with a river or bay.

Tidal Wetland: a type of emergent wetland ecosystem characterized by daily and annual inundation cycles and a perennially wet, high water table, and dominated by emergent vegetation. Woody vegetation such as willow species may be a significant component for some areas, particularly in the western-central Delta.

Upland and Lowland River Floodplain: an ecosystem associated with river processes such as annual flooding, erosion, deposition, and channel migration. Examples include willow thicket, willow riparian shrub, and valley foothill riparian vegetation communities.

Upland Elevation Band: land area that is located at elevations higher than 10 feet above Mean Higher High Water, and not within the Floodplain Elevation Band.

Valley Foothill Riparian Woodland: a natural community type that occurs within Upland and Lowland River Floodplain, consisting of mature riparian trees and dense shrubs including nonconifer species, and including but not limited to sycamores, oaks, willows, and cottonwoods.

Vernal Pool Complex: a type of seasonal wetland ecosystem characterized by seasonally saturated depressions, with a relatively impermeable subsurface soil layer and the distinctive vernal pool plant species listed in Table 1-4 in Appendix 3A.

Wet Meadow: a type of seasonal wetland ecosystem characterized by seasonally saturated depressions.

Willow Riparian Shrub: a natural community type that occurs within upland and lowland river floodplain, consisting of riparian vegetation dominated by woody vegetation or shrubs with few to no tall trees.

Willow Thicket: a natural community type that occurs within upland and lowland river floodplain, is perennially wet and dominated by woody vegetation, and is generally located at the terminus of major creeks or rivers and/or alluvial fans on to the valley floor. Emergent vegetation may be a significant component.

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Appendix C
Attachment C-2.2
Proposed Appendix 8A. Priority Locations to Evaluate Physical Expansion of Channel Width

DRAFT

APPENDIX 8A. Priority Locations to Evaluate Physical Expansion of Channel Width

Delta Plan Amendments

May 2020

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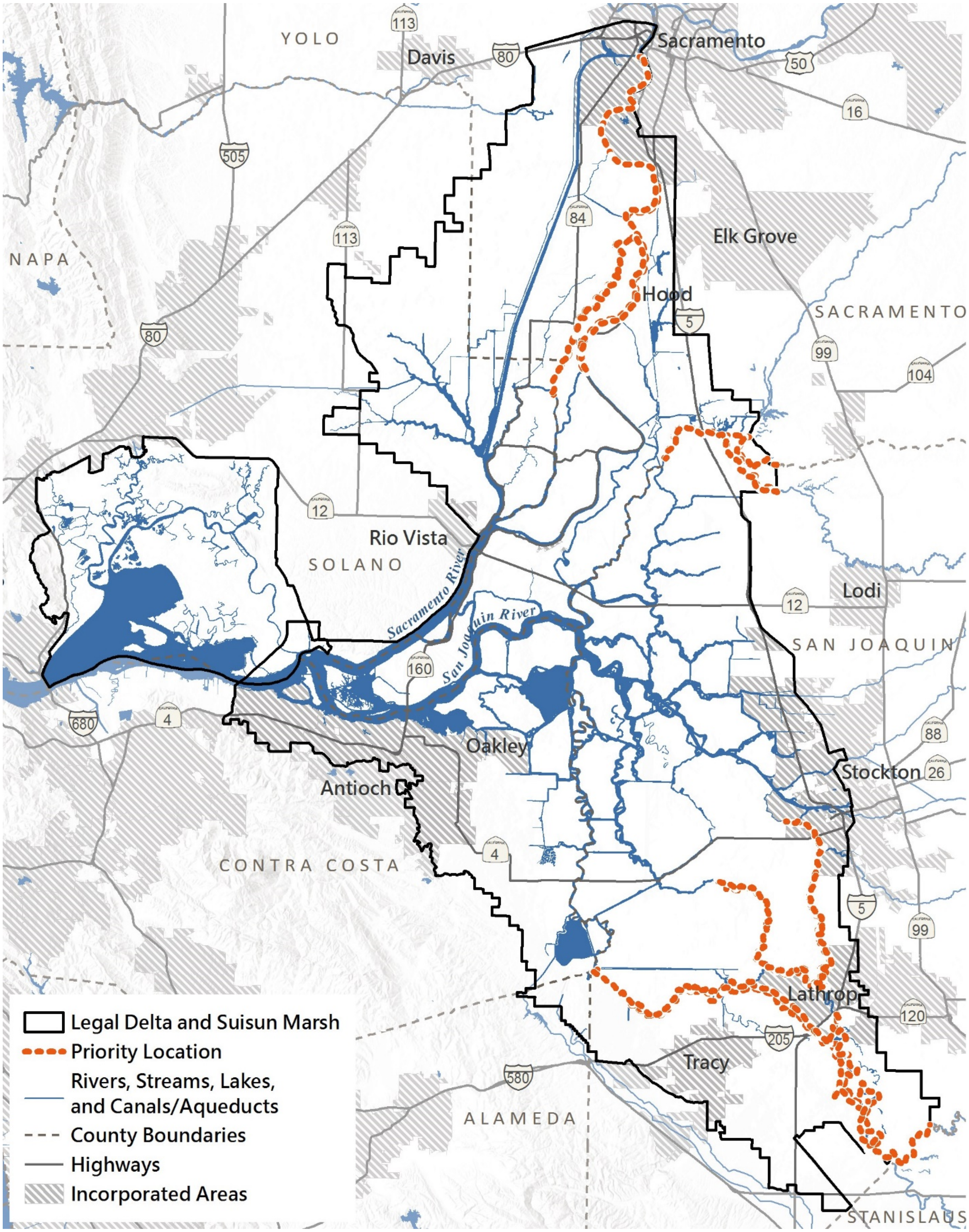

Figure 1. Priority Locations to Evaluate Physical Expansion of Floodplains

Figure 1. Priority Locations to Evaluate Physical Expansion of Floodplains (contd.)

Figure 1 is a map that identifies the Priority Locations to Evaluate Physical Expansion of Floodplains within the Delta, corresponding to the requirements of Ecosystem Restoration Policy 4 (ER P4). Priority locations are shown along select waterways in upstream portions of the Delta. The priority locations are:

- the Sacramento River between the Deepwater Ship Channel and Steamboat Slough, including urban levees in West Sacramento and Sacramento;
- Elk Slough;
- Sutter Slough, from Miner Slough to Elk Slough;
- the Cosumnes River and the Mokelumne River, from the boundary of the Delta to the confluence with Snodgrass Slough;
- the San Joaquin River from the Stanislaus River confluence to Rough and Ready Island, including urban levees in Stockton and levees that run through Lathrop;
- the portion of the Stanislaus River that is within the boundary of the Delta;
- Middle River, from the Old River confluence to the midpoint between Howard Road and Tracy Boulevard;
- Old River, from the San Joaquin River confluence to Hammer Island, including levees that run through Lathrop; and
- Paradise Cut.

Alternative formats of this map are available upon request.

Attachment C-3
Technical Appendices

Appendix C
Attachment C-3.1
Proposed Appendix Q1. Methods Used to Update Ecosystem Restoration Maps Using New Digital Elevation Model and Tidal Data

DRAFT

APPENDIX Q1. Methods Used to Update Ecosystem Restoration Maps Using New Digital Elevation Model and Tidal Data

Delta Plan Amendments

May 2020

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Contents

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Methods Used to Map Elevation Bands

Introduction

Part 1 of this appendix documents the methods employed by Siegel and Gillenwater (2020) to develop the *Map of Elevation Bands for the Protection, Restoration, and Enhancement of Different Classes of Natural Communities* (Map) (Figure 4-5 in Chapter 4 of the Delta Plan) to replace the *Map of Habitat Types Based on Elevation, Shown with Developed Areas in the Delta and Suisun Marsh* (Figure 4-6 in Chapter 4 of the Delta Plan, as adopted in 2013). The new Map reflects current land elevation data, tidal datum data, and sea level rise projections. Two layouts were prepared: one with three intervals of sea level rise shown (Figure 1) and the other combining the sea level rise intervals into a single area (Figure 2).

All input data, analytical steps, and output data sets are described. This includes discussion of:

- Digital Elevation Models (DEM) used for land elevations, derived from recent Light Detection and Ranging (LiDAR) data
- Modeled tidal datums and interpolation methods used to establish tidal elevations across the diked and nontidal landscapes of the Delta and Suisun Marsh
- Sea level rise values applied to show accommodation space
- Setting of shallow subtidal elevations boundary restoration opportunities
- Habitat map units
- Resulting compiled Geographic Information Systems (GIS) data sets

Figure 3 outlines the steps used in preparing the Map of *Elevation Bands for the Protection, Restoration, and Enhancement of Different Classes of Natural Communities* (Figure 4-5 in Chapter 4 of the Delta Plan) and the sections where these steps are described.

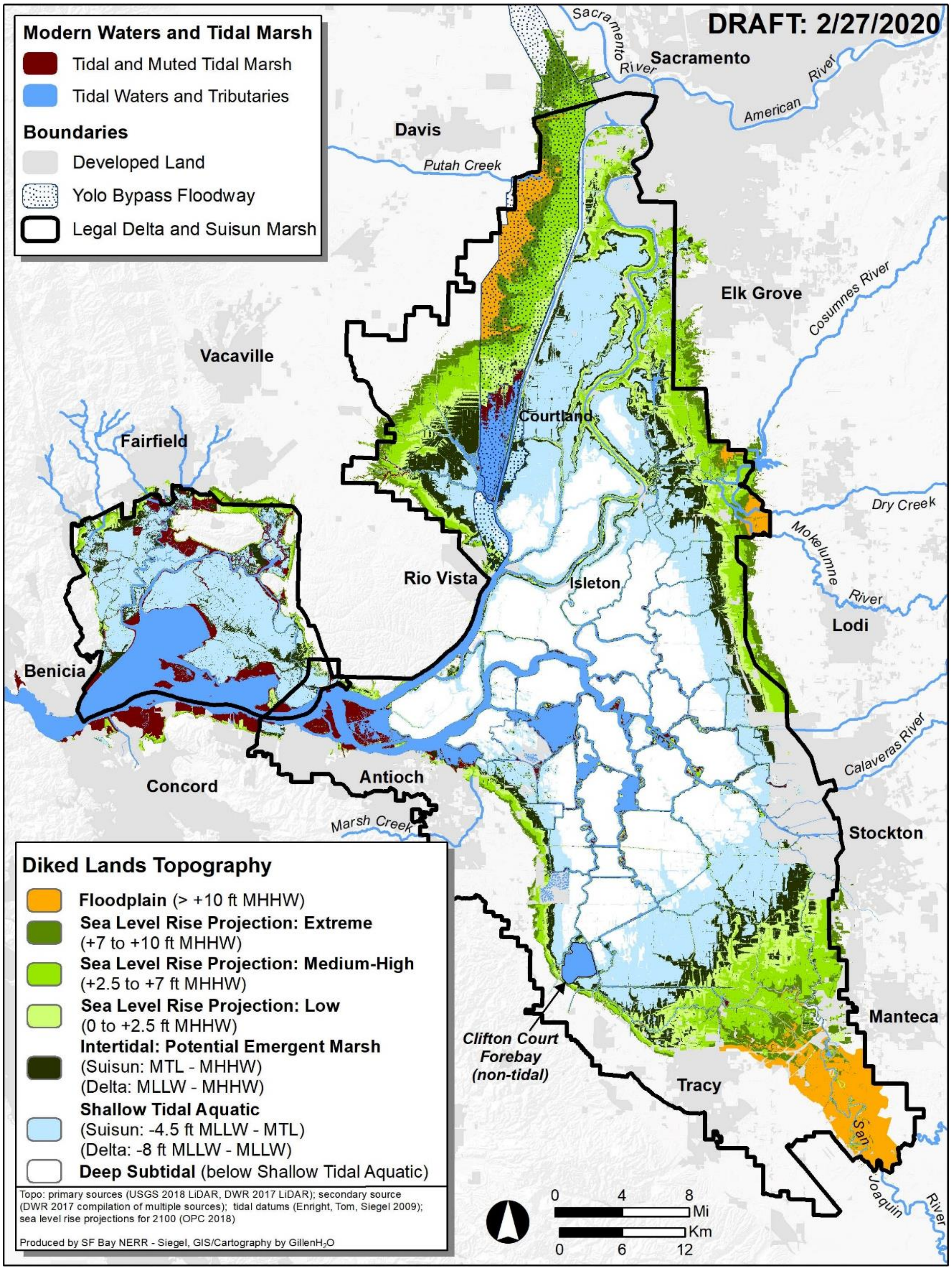

Figure 1. Draft Elevation Bands, Shown with Developed Areas in the Delta and Suisun Marsh – Multiple Sea Level Rise Projections

Figure 1. Draft Elevation Bands, Shown with Developed Areas in the Delta and Suisun Marsh – Multiple Sea Level Rise Projections (contd.)

This map (created on February 27, 2020) illustrates the detailed, draft results of the analysis described in this appendix. The map shows the tidal elevation bands resulting from various projections of sea level rise, including extreme sea level rise (7 feet to over 10 feet mean higher high water), medium to high sea level rise (over 2.5 feet to 7 feet mean higher high water), and low sea level rise (0 to 2.5 feet mean higher high water).

The map also shows topography of diked lands, grouped into habitat types based on elevation. These habitat types and elevation bands include floodplain (greater than 10 feet mean higher high water), intertidal potential emergent marsh (in Suisun Marsh: between mean tide to mean higher high water; in the Delta: between mean lower low water to mean higher high water), shallow tidal aquatic (in Suisun Marsh: between 4.5 feet below mean lower low water to mean tide; in the Delta: between 8 feet below mean lower low water to mean lower low water), and deep subtidal (below shallow tidal aquatic).

This map also shows the extent of tidal and muted tidal marsh habitat and modern tidal waters and tributaries, and the Yolo Bypass floodway. Major cities, rivers, and other features of interest are included for reference purposes.

Alternative formats of this map are available upon request.

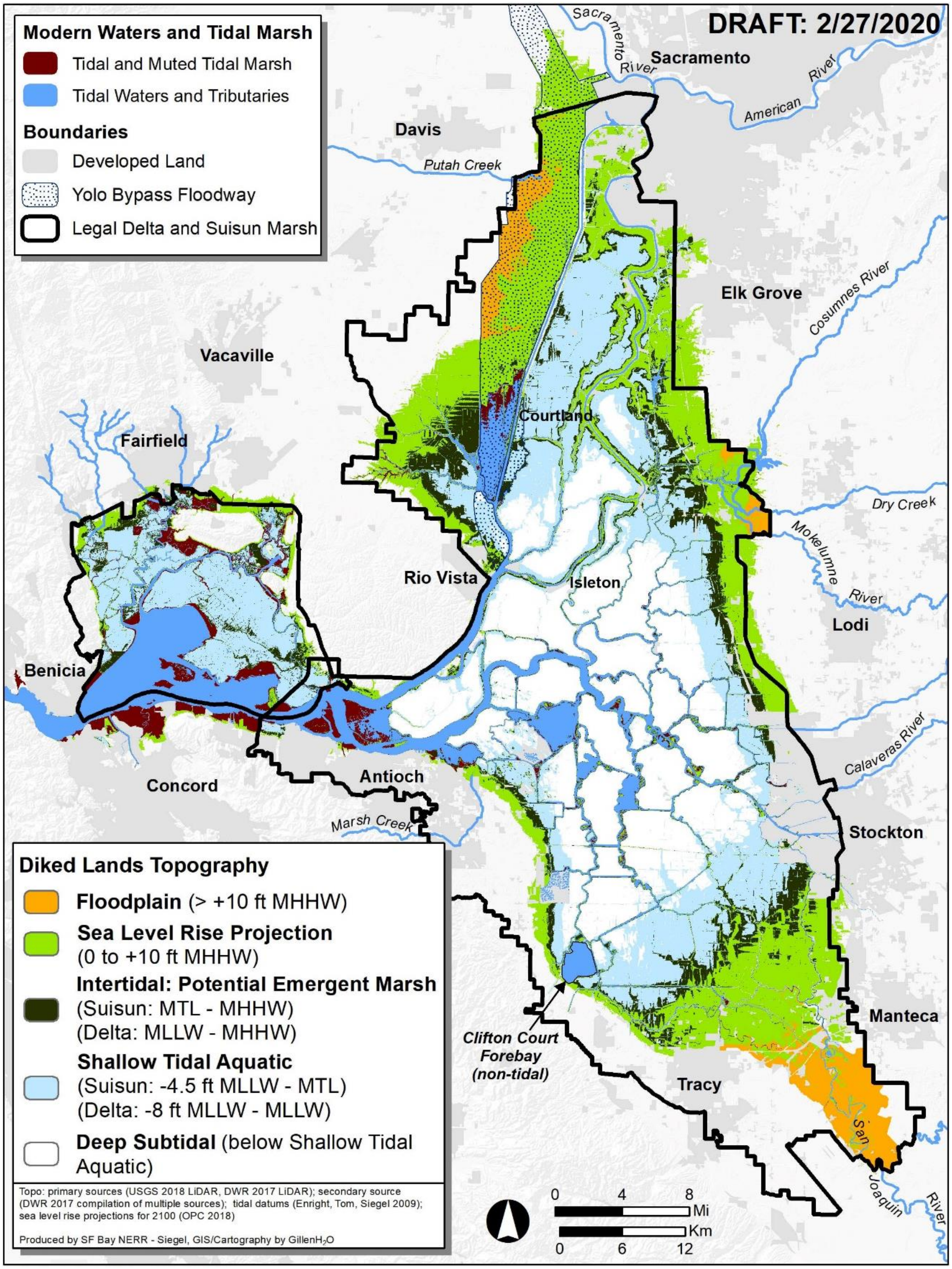

Figure 2. Draft Elevation Bands, Shown with Developed Areas in the Delta and Suisun Marsh – Merged Sea Level Rise Projections

Figure 2. Draft Elevation Bands, Shown with Developed Areas in the Delta and Suisun Marsh – Merged Sea Level Rise Projections (contd.)

This map (created on February 27, 2020) illustrates the consolidated, draft results of the analysis described in this appendix. The map shows the tidal elevations band resulting from various projections of sea level rise between 0 to 10 feet mean higher high water.

The map also shows topography of diked lands, grouped into habitat types based on elevation. These habitat types and elevation bands include floodplain (greater than 10 feet mean higher high water), intertidal potential emergent marsh (in Suisun Marsh: between mean tide to mean higher high water; in the Delta: between mean lower low water to mean higher high water), shallow tidal aquatic (in Suisun Marsh: between 4.5 feet below mean lower low water to mean tide; in the Delta: between 8 feet below mean lower low water to mean lower low water), and deep subtidal (below shallow tidal aquatic).

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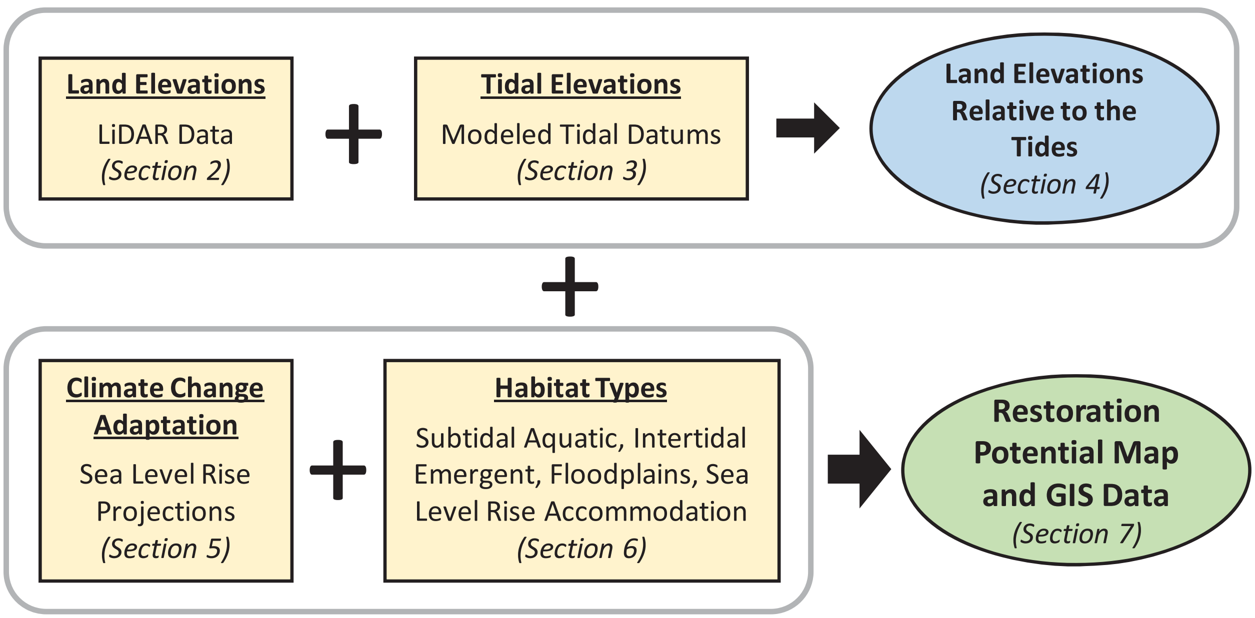

Figure 3. Steps Used in Updating Elevation Band Maps

This diagram illustrates the methods used to develop updated elevation band maps. The diagram shows the different data sets used and how they are combined to develop a restoration potential map. The top of the diagram includes a section with two data sets: (1) land elevations (LiDAR data, discussed in Land Elevations section and (2) tidal elevations (modeled tidal datums, discussed in Tidal Datums Used section. These data sets are used to determine land elevations relative to the tides (discussed in Creation of Tide Range Zones and the Classified DEM section. The bottom half of the diagram includes two additional data sets: (1) climate change adaptation (sea level rise projections discussed in Sea Level Rise Values section and habitat types (subtidal aquatic, intertidal emergent, floodplains, sea level rise accommodation discussed in Section 6). This diagram indicates that the two data sets in the top half and bottom half are combined to develop a restoration potential map and GIS data (discussed in Section 7).

This appendix describes the methods utilized to develop the 2020 version of the Map utilizing newly available 2017-2018 Delta and 2018 Suisun Marsh source LiDAR ground elevation data.

Land Elevations

There are multiple data sets currently available that collectively provide the full geographic extent needed for the Delta Plan Map. These data sets are described in Section 2.1, and the process for creating a single combined data set is detailed in Section 2.2

Digital Elevation Models

Key to producing the new Map is the land elevation data used in the analysis. Each of these data sets and rationale for their selection are described below.

1. **Legal Suisun Marsh** (new data): September 2018 LiDAR flown for and processed by the U.S. Geological Survey (USGS) and available online[1] (the "**USGS 2018 LEAN DEM**" released in 2019). USGS applied a new method, LiDAR Elevation Adjustment with NDVI (LEAN) (Buffington and Thorne 2019). This method utilizes extensive ground-based surveying data and machine learning to correct for the dense, tall emergent vegetation of the diked and tidal marshes that comprise the bulk of lands in Suisun Marsh. This vegetation cover is well-known to obscure ground surface elevations. USGS removed all the tidal waters (bays and sloughs) of Suisun Marsh for its DEM. As part of its DEM generation, USGS carried out validation of the corrected DEM with ground-based topographic data, which indicated that the LEAN correction resulted in a 66 percent improvement in the mean elevation error and a 45 percent reduction in the standard deviation of those errors.

   One question that remained open with this new data set was whether areas of standing water that were present within diked marshes at the time of the September 2018 LiDAR acquisition may have inaccurate ground elevations in the DEM. To address this question, elevations in these areas were compared against the DWR 2017-2018 DEM (see next item). Our initial assumption was that the DEM containing the lower elevation within the flooded areas would be more accurate, which may or may not be entirely valid (Buffington and Thorne 2019). The USGS 2018 LEAN DEM contained the lower elevation in the majority of flooded areas, and when it was higher, it was typically within 0.5 feet (ft) of the DWR 2017-2018 DEM, which is negligible at the scale of land subsidence in the region. It was determined that no adjustments to the USGS 2018 LEAN DEM were warranted for this regional-scale analysis. As has long been known for site-specific restoration planning in diked marshes with extensive cover of tall

[1] https://www.sciencebase.gov/catalog/item/5d140b8ae4b0941bde59934a

emergent vegetation, ground topographic surveys to validate DEM elevations are essential.

2. **Legal Delta** (new data): December 2017 to January 2018 LiDAR flown for the California Department of Water Resources (DWR) (the "**DWR 2017-2018 DEM,**" Woolpert 2019). These data covered the Delta and Suisun Marsh, but here, only data within the Delta data are used, with Suisun replaced by the USGS 2018 LEAN DEM data described above. A LEAN correction has not been applied to the DWR 2017-2018 DEM. Delta lands behind levees are predominantly in agricultural use. In addition, LiDAR flights for this data set were conducted in the winter, when vegetation is less prominent. As such, the value of the LEAN method to correct for tall emergent marsh vegetation is assumed low for this data set.
3. **Lands Outside the Suisun Marsh and Legal Delta** (prior data): In 2017, DWR prepared a Delta-wide DEM from a variety of best available datasets at the time, reflecting various years of data collection. This combined DEM is identified as the "**DWR 2017 Seamless DEM.**" This data set combines a variety of LiDAR data sources for land elevations, incorporates the best available data (at the time of compilation) for the Delta and surrounding uplands, and is the basis for several ongoing planning and analysis efforts in the Delta. This dataset is used for all lands *outside* the extent of the USGS 2018 LEAN DEM and DWR 2017-2018 DEM (essentially outside of the Delta and Suisun Marsh).

Creation of Mosaicked DEM for Analysis

The three DEMs described in Section 0 were mosaicked together to create the single DEM used for this analysis. The methods used to create this mosaicked DEM are as follows, with all spatial analyses performed in ArcGIS 10.7.1.

1. Mosaic the three DEMs into a single DEM
    a. The Mosaic to New Raster tool was used to mosaic the three DEMs together. The mosaic priority order was set as follows to ensure that the appropriate dataset was utilized in the final mosaic DEM:
        i. USGS 2018 LEAN DEM (first priority, overwrites all other datasets)
        ii. DWR 2017-2018 DEM (second priority, overwrites DWR 2017 Seamless DEM)
        iii. DWR 2017 Seamless DEM (third priority, used outside areas of overlap)
    b. The cell size of the mosaicked raster was set to 10 ft (3.05 meters). *Future site-specific restoration planning efforts in the Delta or Suisun Marsh are*

better served by utilizing the appropriate full-resolution DEM, as opposed to this down-sampled mosaic.

2. Clip the mosaicked DEM down to the analysis extent to create the input DEM for subsequent spatial analyses.

    a. A polygon was drawn along the approximate 30 ft NAVD88 contour line around the perimeter of the Suisun Marsh and Delta study area. This polygon represents the maximum extent of topographic analysis in this effort, plus a 10-ft vertical buffer.

    b. This polygon was used in the Extract by Mask tool to clip out the extent of the mosaicked DEM for use in subsequent spatial analyses. This data set represents the *Input DEM* for this project. This data has been archived in an ESRI file geodatabase: Merged_DEM_Feb2020_Clip_Analysis_Extent.fgdbr

Tidal Datums Used

A tidal datum is a set of elevations describing tide heights (e.g., mean high or mean low water) at a point location in an estuary. The tidal datum differs from place to place depending on how tidal energy is dissipated across the geometry of the estuary and how tidal forcing is influenced by river flow inputs. The *spatial* tidal datum is a three-dimensional surface of interpolated point tidal datums that quantified the tidal range and height changes around the estuary. Delta hydrodynamic geometry changes in three general ways: intentional tidal marsh restoration actions, unintentional levee breaches, and direct and indirect modifications to state and federal water project facilities. Delta flows change seasonally, interannually, and from water operations, dam operations, diversions, and exports within and above the Delta. River flows that can be more than double tidal flows in wet years and a fraction of tidal flows in drought years, combined with the effects of all the water operations and in-Delta agricultural diversions, makes the concept of tidal datums inherently more complex than in the tidally dominated lower estuary.

This section describes how tidal datums are calculated (Section 3.1), the preliminary effort to compute them for the Delta in 2007 (Section 3.2), the next improvement in 2008 and 2009 (Section 3.3), the uncertainty remaining today in tidal datums for the Delta (Section 3.4), and a recommended approach to updating tidal datums for the region (Section 3.5).

How Tidal Datums Are Calculated

The National Ocean Service (NOS) is the federal entity charged with promulgating methods for computing tidal datums in the United States and for computing them throughout the nation in support of interstate commerce. NOS utilizes two methods for computing tidal datums:

1. **Reference or Harmonic Station Tidal Datums.** The first method applies to locations where NOS has installed and operated a tide gauge of suitable technical specification for at least 19 years. This duration captures the full 18.6-year cycle of solar and lunar gravitational forces generating tides, known as the *Metonic cycle*. NOS directly calculates datums from these data for periods of time it designates as the National Tidal Datum Epoch (NOS 2001). These tidal datum locations are called *reference* or *harmonic* sites.
2. **Local or Subordinate Station Tidal Datums.** The second method applies where NOS (or any other party) has a shorter record of tides. For those locations, NOS utilizes the Method of Corresponding Tides (MoCT) (NOS 2003). This method compares short-term records at the *local* or *subordinate* station to the synoptic records at the closest NOS reference station, computes the differences for each high and low tide during the short time period, and applies those differences to the reference station datums to establish the local station datums.

Port Chicago, located on the Contra Costa shoreline in Suisun Bay, roughly midway between the Delta to the east and Carquinez Strait to the west, is the nearest NOS reference station to the Delta and Suisun Marsh. There are four other NOS tidal datum reference stations lower in the San Francisco Estuary (San Francisco at the Golden Gate, Alameda, Redwood City, and Richmond). There are no NOS tidal datum reference stations in the Delta, though NOS did install short-term local stations in the past.

First Delta-Wide Tidal Datums Analysis: Initial 2007 Coarse Estimate

The first effort to compile tidal datums across the Delta was done in 2007 by Stuart Siegel for Governor Schwarzenegger's Delta Vision Blue Ribbon Task Force (Siegel 2007). That effort involved compiling all the NOS *local/subordinate* tide stations operated in the Delta up to that point in time, converting the reported tidal datums to a common vertical geodetic datum where possible, assessing the relative quality of the reported datums based largely on their geodetic accuracy, and identifying broad regions of similar tidal datums (the data supported three regions: south, central, and north Delta). That effort made two key findings. First, the available data—12 stations, located mostly in the central interior Delta—were inadequate to represent tidal datums throughout the Delta and did not capture the significant tidal effects of the large and small rivers flowing into the Delta. Thus, the three tidal range zones were very rough approximations. Second, the absence or low stability ratings of geodetic benchmarks translated to low vertical certainty in much of the data, and thus poor ability to compare across the Delta. The result of this effort was identification of the need to improve estimates of Delta tidal datums. That effort took place in 2008 and 2009 and is described in the next section.

Currently Best Available Data, Used Here: 2009 DWR Tidal Datums Computations

Following completion of the initial 2007 coarse tidal datum estimates, Stuart Siegel worked with Chris Enright and Brad Tom at DWR in 2008 and 2009 to develop a comprehensive tidal datum data set for the Delta that data available at that time could support, as the first step to remedy these problems. At the time, this group identified that the effort itself, while a major improvement, still had limitations. These data are used here, as no suitable improvements have yet been made to it.

That analysis used hydrodynamic modeling to calculate tidal datums (utilizing the NOS 2003 MoCT methodology) throughout the Delta and up each river and stream at a high node density. It calibrated and verified model results with about five years of verified field observational water level data (from 2000 to 2005) for dozens of long-term DWR and USGS Delta stage data stations distributed far more widely across the Delta than the twelve NOS stations.

The DWR modeling effort calculated tidal datums for the entirety of the multiyear modeling period (“all data” tidal datums) and for subannual time periods (“subannual” tidal datums) reflecting Delta Cross Channel closure (closed February through mid-May; a portion of mid-May through June; and a portion of November and December), and the annual installations of the south-Delta temporary barriers at Head of Old River (closed from mid-September to end of November), Old River near Tracy, Middle River, and Grant Line Canal (all closed mid-April to the end of September). These subannual subsets of the data reveal seasonal variability in the tidal datums, resulting in variations in local tide ranges of up to 2 feet in some locations. This Delta Plan map uses the “all data” tidal datums. When planning actions such as restoration projects where the tidal datums at certain times of year are critical, it may be appropriate to utilize the subannual tidal datums specific to that time period.

Completion and publication of that effort has not yet occurred due to absence of funding support. The work completed to date is referenced as Enright et al. (2009). The suggested approach to its completion is described below in Section 3.5.

Disclosure on Uncertainty of Tidal Datums Used

It is important to disclose two key limitations of the tidal datums used in this effort:

1. All Delta tidal datum computations utilizing the Method of Corresponding Tides (NOS 2003) have no choice but to use the Port Chicago NOS tidal datum reference station, as there are no such NOS stations within the Delta. The tidal hydrology of Suisun Bay where Port Chicago is located is very strongly

influenced by tides through the Golden Gate. In contrast, the tidal hydrology of the 750,000-acre Delta is very strongly influenced by river flows, water operations within and above the Delta, and so forth, and these processes have strong geographic variability around the Delta. Consequently, utilizing Port Chicago as the reference station introduces uncertainty into the computations, and the amount of that uncertainty has not been calculated, nor is it a simple task to calculate.

2. The results of the effort described in Section 0 are calibrated and verified using a roughly five-year data set of water level observation stations in the Delta and Suisun Bay. These time periods are well below the 18.6-year tidal epoch time period. This is less of a concern for Suisun Marsh as Port Chicago is reasonably reflective of tides in Suisun Bay. It is more of a concern in the Delta given the above discussion about there being no Delta NOS reference stations to utilize for the computations.

Recommendation for Developing Newly Updated Tidal Datums

The best tidal datum calculations follow the NOS approach of having an 18.6-year continuous data record or longer at water level recording stations with high geodetic accuracy (see Section 3.1 above). Such data sets now exist, as sufficient time has passed for a large number of geographically dispersed water level recording stations that have been operated by DWR and USGS. The basic approach to compute data-derived tidal datums is to compile the most recent 18.6 years of data from each of these stations, validate both sensor functionality and geodetic basis for each station to ensure suitable data quality or at a minimum to be able to assess uncertainty for each data station, directly calculate the tidal datums for each station, use these data as calibration and verification data for hydrodynamic modeling across the entire Delta and Suisun Bay, update the tidal datum zones for the Delta and Suisun Bay, and apply these updates to the topographic data. Given the complexity of this effort and its policy importance, submitting this work through a scientific peer-reviewed journal would provide the highest level of confidence in tidal datums for this region. A partial draft manuscript has been developed (Siegel et al., in preparation).

Creation of Tide Range Zones and the Classified DEM

The Suisun Marsh and Delta diked and nontidal lands study areas require division into a series of tide range zones, which are used to segment (classify) the underlaying terrestrial topography (represented by DEM described in Section 2) for visualization and analysis of the various elevation classes of interest to this effort (i.e., subtidal, intertidal, sea level rise accommodation space). As described in the previous section, this analysis uses the “all data” hydrodynamic model results (Enright et al. 2009) for determination of regional tidal datums. The methods used to create the tide range zones and classified DEM are as follows, with all spatial analyses performed using ArcGIS 10.7.1.

Creation of Tide Range Zones

1. Import the Enright et al. (2009) hydraulic model nodes for mean lower low water (MLLW) and mean higher high water (MHHW) in the waterways
2. Interpolate grids of MHHW and MLLW across the diked lands between tidal waterways, using the modeled water surface elevation at hydraulic model nodes
   - Digitize the interpolation boundary polygon at the ~30 ft NAVD88 contour around the study area, incorporating the split between the Yolo Bypass and Clarksburg Agricultural District along the Sacramento Deep Water Ship Channel (see discussion below)
   - Use the Inverse Distance-Weighted (IDW) interpolation tool to create the diked and nontidal lands tidal datum grids
     - 300-meter (m) output grid resolution
     - Variable search radius (minimum 12 interpolation points)
     - Interpolation boundary set as described above
3. Reclassify the resulting MHHW and MLLW diked and nontidal lands grids into elevation bands using the Reclassify tool
   - 1 ft bands centered on 1 ft intervals (e.g., 5.5 to 6.5 ft)
4. Convert the reclassified MHHW/MLLW diked and nontidal lands grids to polygons using the Raster to Polygon tool
   - Assign the mean elevation of each band to the resulting polygons (e.g., 5.5 to 6.5 ft is assigned an elevation of 6 ft)
   - Edit the polygons to remove slivers and other anomalies
5. Perform a spatial union of the MLLW and MHHW polygons to create the diked and nontidal lands tide range zone polygons using the Union tool
   - e.g., overlap of the 1 ft NAVD88 MLLW polygon with the 6 ft NAVD88 MHHW polygon is assigned a tide range class of 1 to 6 ft NAVD88
   - Edit the resulting polygons to remove slivers and other anomalies
   - *Final tide range zone shapefile: Tide_range_ALL_polys_IDW1_1ft_bin_simplify.shp*

Clarksburg Agricultural District and Yolo Bypass Tidal Datums

The Clarksburg Agricultural District in the Netherlands area of the northern Delta and the Yolo Bypass present a setting that required selecting which tidal datums to use, given relatively large tidal datum differences between the Sacramento River, Sacramento Deep Water Ship Channel, and Yolo Bypass Toe Drain.

Clarksburg Agricultural District. This area is bordered on the west by the tidal, dead-end Sacramento Deep Water Ship Channel and on the east by the tidal Sacramento River. To determine how to apply the waterways tidal datum data to this area, the connection of potential restoration efforts to tidal sources was considered. Early planning of the DWR Prospect Island restoration project made clear that the Bar Pilots Association advocates for no breaches to the Ship Channel in order to avoid introducing cross-current navigation challenges. Based on that knowledge, and in consultation with Council staff, this effort applies Sacramento River tidal datums to the entirety of the Clarksburg Agricultural District.

Yolo Bypass. The Yolo Bypass Toe Drain runs along the east side of the Yolo Bypass along the western toe of the levee that functions as both the western Ship Channel and eastern Yolo Bypass hydraulic boundaries. The Toe Drain is subject to tidal action along much of its length, receives inflows from local tributaries (e,g., Putah Creek) as well as major winter flood conveyance, and is hydrologically isolated from the Ship Channel by the levee. Tidal datums for Yolo Bypass have been set based on modeled Toe Drain tidal datums, based on the same assumption for not breaching into the Ship Channel applied for Clarksburg and that Ship Channel levee breaches might affect the flood conveyance functions of the Yolo Bypass. The validity of these assumptions could change in the future, but for the present, they are deemed appropriate.

Creation of the Classified DEM

1. Use the tide range zone polygons to clip out individual sub-DEMs for each zone (17 DEMs total) from the Input DEM using the Extract by Mask tool
2. Classify each of the sub-DEMs into the elevation classes of interest based on the assigned tide range using the Reclassify tool. The elevation classes are described in detail in the “Habitat Map Units” section, below.
3. Merge the 17 classified sub-DEMs into a complete classified DEM of the Delta and Suisun Marsh using the Mosaic to New Raster tool.
4. Delineate the extent of “floodplain” habitat within the Yolo Bypass, Mokelumne-Cosumnes, and south-Delta regions (see discussion in the “Floodplain Delineation” section, below). Merge the “floodplain” habitat class into the classified DEM using the Mosaic to New Raster tool.

5. Remove tidal waters and tidal marshes from the classified DEM so that all computational analyses consider only diked lands with tidal or floodplain (nontidal) restoration potential. USGS removed the tidal waters in its 2018 LEAN DEM.

   - **Removing tidal marshlands**. A GIS dataset of all natural and restored tidal marshes throughout the San Francisco Estuary was used. This data set is founded on the EcoAtlas developed by the San Francisco Estuary Institute and improved by Stuart Siegel and his collaborators over many years as part of a variety Final classified DEM: Merged_DEM_Feb2020_Clip_Analysis_Extent_Reclass_FINAL.tif
   - This classified DEM retains data within the currently mapped extent of tidal waters, tidal/muted tidal wetlands, and developed/urban areas. These areas will need to be removed from the DEM before any quantitative analysis of the DEM is performed.

Sea Level Rise Values

This map update utilizes the most recent Ocean Protection Council (OPC 2018) values for three ranges of projected sea level rise at the Golden Gate (outer coast) for the year 2100 (Table 1). The degree of sea level rise within Suisun Marsh and the Delta associated with these predictions for the outer coast is difficult to forecast due to interactions with river flows, tidal restoration efforts, and potential future human sea level rise adaptation efforts (e.g., salinity barriers, wetland restoration, levee setbacks, sea walls). Therefore, the sea level rise values shown on the map are merely contour lines of higher water associated with the outer-coast sea level rise values, and do not reflect physical transmission of sea level at the Golden Gate into the Delta, nor the effects of sea level rise adaptation efforts. This effort also rounded sea level rise projections to the nearest half-foot, so as not to reflect the inherent uncertainties across all the data when together.

Table 1. Sea Level Rise Projections for 2100 Used in Mapping

OPC SLR Scenarios [1]	OPC 2100 SLR Values [2]	Adopted SLR Values for Delta Plan Map [3]
Low	**RCP 2.6 = 2.4 feet** RCP 8.5 = 3.4 feet	2.5 feet
Medium to high	RCP 2.6 = 5.7 feet **RCP 8.5 = 6.9 feet**	7.0 feet
Extreme	**H++ = 10.2 feet**	10.0 feet

Notes:

[1] OPC lists sea level rise scenarios in terms of “risk aversion.” OPC states “Risk tolerance is the level of comfort associated with the consequences of sea level rise and associated hazards in project planning and design. Risk aversion is the strong inclination to avoid taking risks in the face of uncertainty.” Thus, low risk aversion equates to scenarios of lower sea level rise, high risk aversion equates to scenarios of higher sea level rise.

[2] Sea level rise scenarios utilized in and described by OPC (2018):

a RCP 2.6 is the “low end” sea level rise scenario that requires significant global emissions reductions to achieve.
b RCP 8.5 is the “high end” business-as-usual, fossil-fuel intensive emissions scenario.
c H++ is the extreme sea level rise scenario reflecting uncertain projections of high rates of Antarctic and Greenland land ice-sheet loss to the ocean.

[3] For purposes of the Delta Plan map preparation:

a SLR values rounded to nearest 0.5-foot in consideration of multiple sources of uncertainty.
b “Low” uses RCP 2.6 (low risk and low emissions) to reflect optimistic SLR projections.
c “Medium-high” uses RCP 8.5 as it represents current emissions levels and trends globally.

Map Units

The units used to symbolize topography in the map of elevation bands (Figures 1 and 2) are provided in Table 2.

Table 2. Mapping Units Elevation Ranges and Habitat Types

Mapping Elevation Unit	Elevation Range		Habitat Types
	Delta	Suisun Marsh	
Uplands	Lands above sea level rise accommodation elevations		Dry land habitats, seasonal wetland complexes, riparian corridors, etc.
Floodplains			
Floodplain	Lands above the "extreme" sea level rise accommodation class within the Yolo Bypass and the lower Mokelumne-Cosumnes River and lower San Joaquin River corridors. Overlap exists between today's floodplain areas and their associated sea level rise accommodation space.		Existing and potential future floodplain habitat above the potential sea level rise elevations
Sea Level Rise Accommodation			
Extreme	+7 ft MHHW to +10 ft MHHW		Potential future emergent tidal marsh, currently lands not subject to tidal action
Medium-high	+2.5 ft MHHW to +7 ft MHHW		
Low	MHHW to +2.5 ft MHHW		
Intertidal Emergent Tidal Marsh			
Emergent marsh potential	MLLW to MHHW	MTL[1] to MHHW	Tidal marsh supporting emergent vegetation
Intertidal and Subtidal Open Water			
Intertidal open water[2]	NA	MLLW to MTL	Tidal aquatic – daily submerged/exposed without emergent vegetation
Shallow subtidal[2]	-8 ft MLLW to MLLW	-4.5 ft MLLW to MLLW	Diked lands suitable for subsidence reversal[3] then tidal restoration by 2100
Deep subtidal	Below -8 ft MLLW	Below -4.5 ft MLLW	Diked lands too low for subsidence reversal to emergent tidal marsh elevation by 2100

Notes
[1] MTL: mean tide level (arithmetic mean of MHW and MLW per NOS 2000)
[2] Intertidal open water and shallow subtidal units are combined on the map as "Shallow Tidal Aquatic" and are retained as separate polygons in the GIS data set to support subsequent analyses.
[3] Subsidence reversal thresholds were calculated by Council staff based on OPC (2018) sea level rise estimates and published organic matter accretion rates throughout the estuary (see Methods Used for Setting Subtidal Subsidence Reversal Elevations section**Error! Reference source not found.**).

Subtidal Habitat Delineation

The threshold used to delineate between shallow subtidal and deep subtidal was developed using methods described in Methods Used for Setting Subtidal Subsidence Reversal Elevations section of this appendix.

Floodplain Delineation

Existing and potentially restorable floodplain habitat is present within the Yolo Bypass and along the lower Mokelumne-Cosumnes and San Joaquin (South Delta) river corridors. For the purposes of this analysis, the "floodplain" elevation class is defined as all lands above the highest sea level rise class (> + 10 ft MHHW) that fall within the floodplain footprint in each of these geographic areas. The floodplain footprint in each area was defined as follows:

- **Yolo Bypass**: All areas within the Yolo Bypass footprint with elevations above the highest sea level rise class, clipped to the Delta boundary.
- **Mokelumne-Cosumnes**: All areas within the Mokelumne-Cosumnes watershed polygons (from CalWater GIS data) cross-checked with the 100-year FEMA floodplain extent, with elevations above the highest sea level rise (SLR) class, clipped to the Delta boundary.
- **South Delta**: All areas within the FEMA 100-year floodplain extent, with elevation above the highest SLR class, clipped to the Delta boundary. The northwest extent of floodplain shown (along the axis of the Delta) was terminated at the approximate extent of floodplain shown on the previous version of the map (*Map of Habitat Types Based on Elevation, Shown with Developed Areas in the Delta and Suisun Marsh [Figure 4-6 in Chapter 4 of the Delta Plan, as adopted in 2013]*).

The individual floodplain class DEMs were created as follows:

1. Use the digitized floodplain bounding polygons to clip out sub-DEMs from the classified DEM (see Section 0) using the Extract by Mask tool.
2. Convert all lands classified as "uplands" in these sub-DEMs into a new "floodplain" class using the Reclassify tool.

These new floodplain class rasters were merged back into the overall classified DEM, as described in Section 0.

Generation of the Final Elevation Band Maps

The input datasets used in the preparation of the final maps are detailed in Table 3. The final map is presented in Figure 1 showing sea level rise accommodation in the three categories described in Table 2, and in Figure 2 with those three categories merged into a single category.

Table 3. Input Datasets to Final Map

Data Type	Filename	Citation[1]	Use Summary
Elevations and Land Uses			
Diked Lands Topography (DEMs)	Merged_DEM_Feb2020_Clip_Analysis_Extent_Reclass_FINAL.tif	GillenH$_2$O and SF Bay NERR, 2020; *built from DWR (2017, 2019) and USGS (2019) datasets*	The classified DEM is symbolized based on the habitat map units described above
Developed Land	2014_2016_DeltaCountiesMerge.shp	DSC, 2018; *built from California FMMP land cover data for Delta counties (2014-2016)*	Landcover types “D” (urban and built-up land), “R” (rural residential land), and “V” (vacant or disturbed land) were symbolized as “developed” and excluded from the analysis
	Legacy_Communities.shp	DSC, 2013: *built from Yolo, Sacramento, and Contra Costa Counties’ land use data*	This file was used to show the development footprint of legacy communities within the Delta, which may not be adequately captured by the FMMP dataset
Waterways and Marshes			
Tidal and Muted Tidal Marsh	Current_modern_baylands_June2014_ tidalmarsh_only.shp	WWR, 2014; *built from SFEI EcoAtlas (1998) with periodic updates to keep current*	This layer contains all tidal and muted tidal wetlands within San Francisco Bay and Suisun Marsh, and was used to symbolize their extent within Suisun Marsh
	CacheSuisunDelta_NaturalCommunities_ Hydro_20140108.shp	WWR, 2014; *compiled from various existing natural community datasets (primarily CDFW 2007 Delta natural communities’ dataset) and updated to distinguish tidal and nontidal settings*	This layer contains a complete classification of the natural communities within the Delta and some areas of Suisun Marsh. The layer was symbolized to show the extent of tidal and muted tidal marshes within the Delta

Table 3. Input Datasets to Final Map (contd.)

Data Type	Filename	Citation[1]	Use Summary
Tidal and Muted Tidal Marsh (contd.)	Flooded_Island-Aquatic.shp	WWR, 2008; *built from 2007 CDFW vegetation data*	This layer was used to symbolize the extent of tidal marsh in the Browns Island-Sherman Lake area, as it was not adequately depicted by the other two datasets
Tidal Waters	CSCCA_CDFG_DeltaSuisun_TidalHyrology_ WWR20130724.shp	WWR, 2013; *built from CDFW (2000) and BDCP (2010) hydrology data*	This layer was used to symbolize the tidal waterways within Suisun Marsh and the Delta
	Current_modern_baylands.shp	WWR, 2014; *built from SFEI EcoAtlas (1998) with periodic updates to keep current*	This layer was used to symbolize the tidal waterways at the extreme western end of Suisun Marsh, which was not captured by the above layer
Tributaries	Delta_River_input.shp	WWR, 2008; *built from various input datasets*	This layer contains the alignments of the major rivers and creeks flowing into the Delta
	Major_suisun_creeks.shp	WWR, 2008; *built from various input datasets*	This layer contains the alignments of the major creeks flowing into Suisun Marsh
	DP_Waterway_additions_Lines.shp	CH2M Hill (no date provided)	This layer contains the alignments of major rivers and creeks flowing into Suisun Marsh and the Delta. It was used to supplement the Delta_River_input.shp file, which did not have complete coverage of the Cosumnes River and Dry Creek alignments within the map extent

Table 3. Input Datasets to Final Map (contd.)

Data Type	Filename	Citation[1]	Use Summary
Legal Boundaries, Roads, Hillshade Relief			
Yolo Bypass Floodway	Yolo_baypass_complete.shp	WWR, 2010; *built from DWR and URS data (2007)*	This layer contains the complete extent of the Yolo Bypass floodway
Legal Delta Boundary	Legal_delta_UTM.shp	DWR, 2002	Represents the boundary of the Delta established under the 1992 Delta Protection Act (primary and secondary zones)
Suisun Marsh Boundary	SMPP_total_outline_Mar2011_diss.shp	WWR, 2011; updated in collaboration with BCDC	Represents the boundary of Suisun Marsh under the 1977 Suisun Marsh Protection Plan (primary and secondary management areas)
Hillshade (background)	HS_Regional_topo_az315.fgbdr	URS, 2008	Regional topographic hillshade layer used as the map background

Key:
BCDC = San Francisco Bay Conservation and Development Commission
BDCP = Bay-Delta Conservation Plan
CDFW = California Department of Fish and Wildlife
DSC = Delta Stewardship Council
DWR = California Department of Water Resources
FMMP = Farmland Mapping and Monitoring Program
GillenH_2O = Gillenwater Consulting, LLC
NERR = National Estuarine Research Reserve
SFEI = San Francisco Estuary Institute
USGS = United States Geologic Survey
WWR = Wetlands and Water Resources, Inc.

Methods Used for Setting Subtidal Subsidence Reversal Elevations

Subsidence Reversal Calculations

The Delta and Suisun Marsh include a gradient of subsided land elevations, with some lands more than 20 feet below current water surface elevations, and others less deeply subsided. A key threshold in restoration planning is the land elevation relative to water surface elevation, where above which, subsidence reversal activities could result in the ability to restore hydrologic connectivity. In deeply subsided areas, current subsidence reversal activities do not increase land elevation at rates which could keep up with sea level rise. In less subsided areas, current subsidence reversal practices could increase land elevations over decadal time frames and ultimately lead to opportunities to create hydrologically connected ecosystems such as tidal marsh. The following section describes the methods and assumptions used to estimate this threshold, which has been used as a criterion to delineate shallow tidal aquatic and deep subtidal on the elevation band maps, and in performance measures related to subsidence reversal.

The methods for calculating the subsidence reversal threshold elevation involves adding elevation change from subsidence reversal (SR) to elevation change from sea level rise (SLR) (C. Copeland, personal communication). This *threshold* is determined by analyzing projected change in sea level rise, an empirically derived subsidence reversal rate, and application over the Delta Reform Act planning horizon. Due to differences in subsidence reversal rates in the Delta and Suisun Marsh, two separate calculations have been carried out.

Delta

Sea level rise for the Delta is expressed as:

$$\Delta SLR = -2.5 \text{ ft}$$

2.5 feet is the median projection for sea level rise in the high emission scenario for San Francisco by 2100 from the Ocean Protection Commission (OPC) guidance (2018).

$$\Delta SR = 4 \text{ cm/year} * 80 \text{ years} * 0.0328 \text{ ft/cm} = 10.98 \text{ ft}$$

The subsidence reversal accretion rate of 4 cm/year comes from the Miller et al. empirical study in the Delta (2008). Based on a start date of 2020, and an end date of 2100 (corresponding to the Delta Reform Act subgoals and strategies for the Delta ecosystem), the change was applied over an 80-year timeframe.

Then: $\Delta SLR + \Delta SR = 7.98$ ft (rounded to 8 ft)

Subsidence Reversal Threshold = -8 ft MLLW

Suisun Marsh

The following analyses are based on methods developed specifically for Suisun Marsh (C. Copeland, memorandum, February 25, 2019).

Managed wetlands on Twitchell Island have been observed accreting 4 cm/year of elevation (Miller et al. 2008). The majority of this accretion occurs through the deposition of organic material onto the surface. Although similar subsidence reversal is possible in Suisun Marsh, the rates of accumulation will likely be slower due to the saline conditions limiting production of organic material. Currently, no empirical data for subsidence reversal activity in Suisun Marsh exists. In order to estimate how a subsidence reversal project in the western Delta (Twitchell Island) accumulates elevation compared to rates of accumulation in Suisun Marsh, accumulation rates for nonsubsidence reversal wetlands were compared. Proxy locations in Suisun Marsh (Rush Ranch) and the western Delta (Brown Island) were used. A ratio was developed between wetland accumulation at each site of .65 units of accretion in Suisun Marsh per 1 unit in the western Delta (Table 4) based on data for those sites from Callaway et al. 2012.

Table 4. Wetland Accretion at Proxy Sites (based on data in Callaway et al. 2012)

Site (Mid)	Dating Method		
	137 Cs	137 Cs	Mean
Browns Island	.40 cm/year	.32 cm/year	.36 cm/year
Rush Ranch	.26 cm/year	.21 cm/year	.24 cm/year
Rush Ranch to Browns Island ratio	.65 to 1	.66 to 1	.65 to 1

A ratio-adjusted accumulation rate for Suisun Marsh was fed into the formula.

$\Delta SLR = -2.5$ ft

2.5 ft is the median projection for sea level rise in the high global greenhouse gas emission scenario for San Francisco by 2100 from the Ocean Protection Commission (OPC) guidance (2018).

$\Delta SR = 4$ cm/year*80 years*0.0328 ft/cm*.65 (ratio adjustment) = 6.82 ft

Based on a start date of 2020 and an end date of 2100 (corresponding to the Delta Reform Act subgoals and strategies for the Delta ecosystem), the change was applied over an 80-year timeframe.

Then, ΔSLR+ΔSR = 4.32 ft (rounded to 4.5 ft)

Subsidence Reversal Threshold = -4.5 ft MLLW

Methods Used to Update Priority Locations to Evaluate Physical Expansion of Floodplain

This section provides a description of methods employed to update priority locations for Delta Plan Policy ER P4: Expand Floodplains and Riparian Habitats in Levee Projects (23 California Code of Regulations section 5008). The original locations specified for this policy were included as a text description in the 2013 Delta Plan (Appendix 3) and on a map in Appendix 8, Figure 8-1. The updated priority locations for ER P4 are illustrated in Figure 4-4 and Appendix 8A. Priority locations were updated using the new digital elevation models and tidal datums, as described below. Locations were selected based on landscape suitability with respect to tidal or floodplain reconnection, which resulted in removing areas in the subsided central and eastern Delta and adding additional areas in the north and south Delta.

The priority locations were selected based on geomorphic processes and opportunities for ecosystem restoration, using the following steps:

1. Selected levee centerline segments (DWR 2017) within:
    a. priority fish migration pathways (SFEI-ASC 2018, EWG 2008, Blue Ribbon Task Force 2008)
    b. adjacent to lands that were categorized as “shallow,” “intertidal,” “floodplain,” “potential emergent marsh” under current and projected sea level rise scenarios, within the Draft Elevation Band Map (see Methods Used to Map Elevation Bands section, Table 3 and Figures 1 and 2). For a full description of how these elevations were classified and methodology associated with the sea level rise scenarios, see the description in Methods Used to Map Elevation Bands section of this appendix.
2. Removed levee segments that were:
    a. outside of the Delta or Suisun Marsh

b. along the Toe Drain of the Yolo Bypass

c. overlapping with the Freeport Regional Water Project Intake Facility

d. adjacent to currently developed areas, as visible in National Agriculture Imagery Program (NAIP) imagery (USDA 2018) in the cities of Sacramento, West Sacramento, and Delta legacy towns

e. segments adjacent to areas with construction visible in NAIP imagery (USDA 2018)

f. segments adjacent to bridge footings

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Appendix C
Attachment C-3.2
Non-substantive Revisions to Proposed Appendix Q1. Methods Used to Update Ecosystem Restoration Maps Using New Digital Elevation Model and Tidal Data

Appendix C
Attachment C-3.2

Non-substantive Revisions Since May 2020 to Proposed Delta Plan Appendix Q1. Methods Used to Update Ecosystem Restoration Maps Using New Digital Elevation Model and Tidal Data

Page Q1-2

The below map was revised to align with the Delta Plan map formatting style. No data were changed.

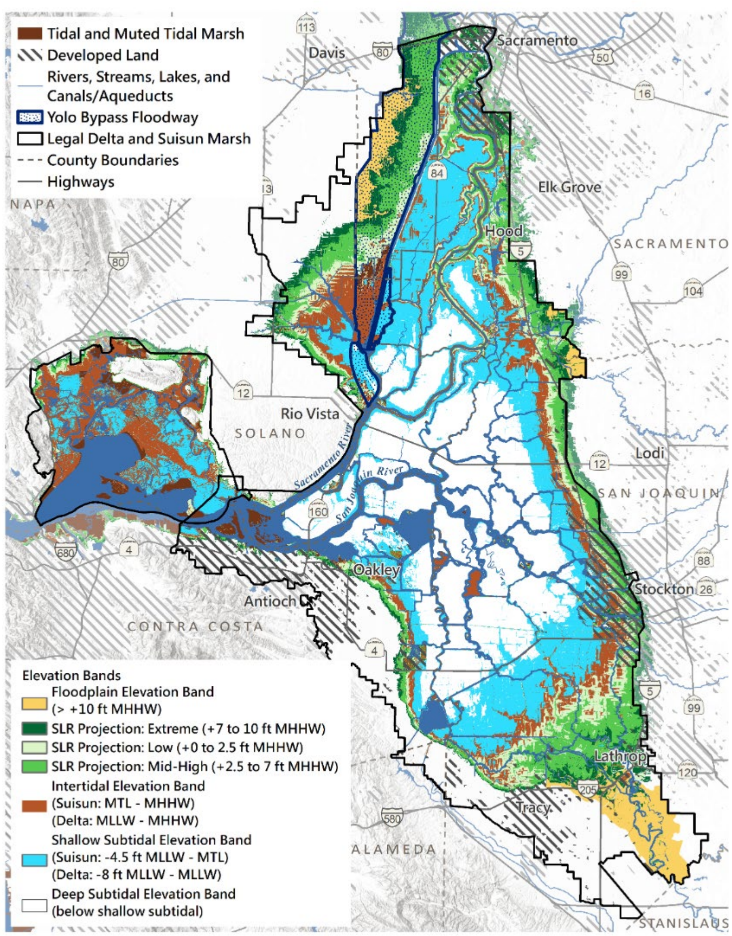

Figure Q1-1
Elevation Bands, Shown with Developed Areas in the Delta - Multiple Sea Level Rise Projections

Page Q1-4

The below map was revised to align with the Delta Plan map formatting style. No data were changed.

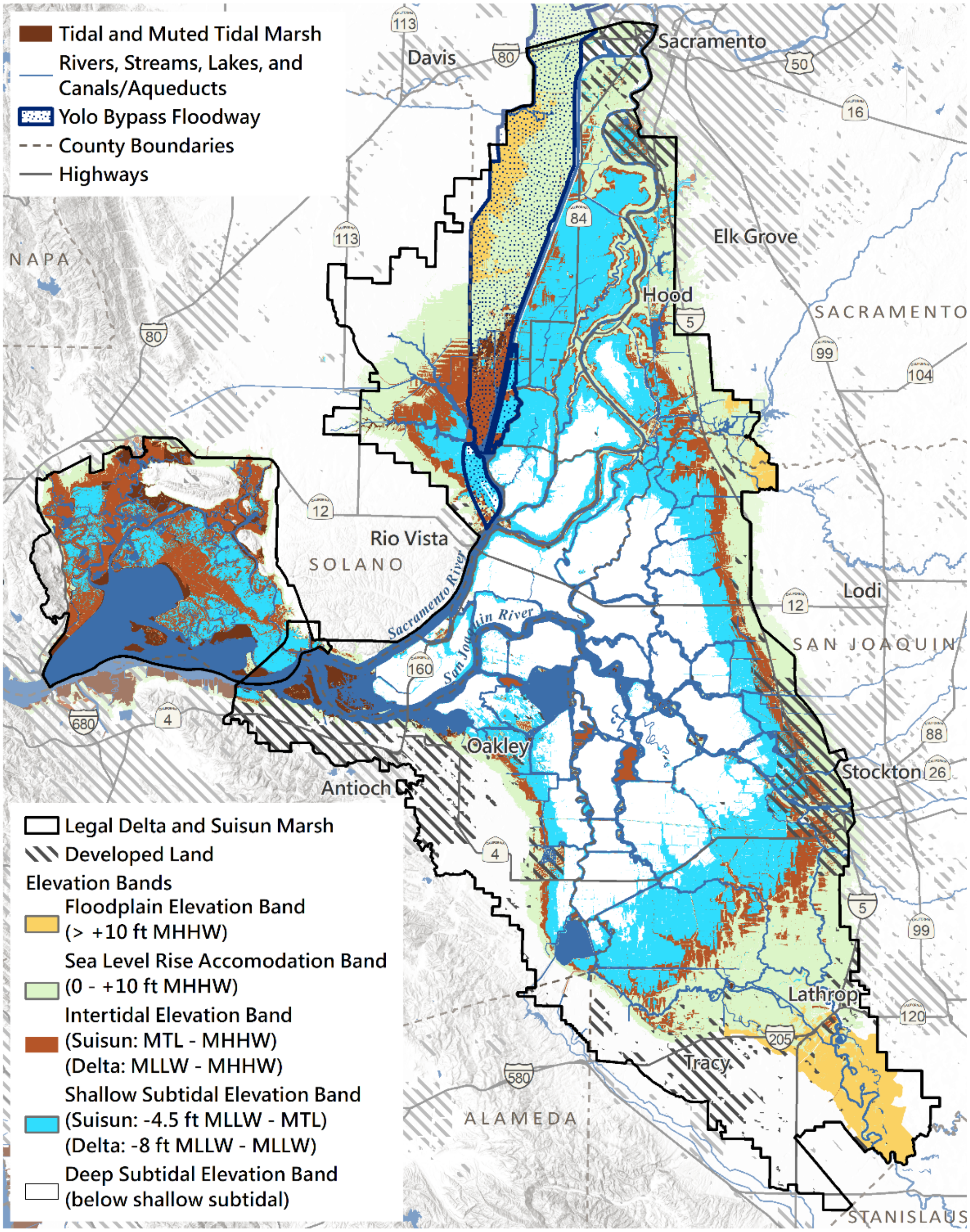

Figure Q1-2
Elevation Bands, Shown with Developed Areas in the Delta - Merged Sea Level Rise Projections

Appendix C
Attachment C-3.3
Proposed Appendix Q2. Key Considerations and Best Available Science for Protecting, Restoring, and Enhancing the Delta Ecosystem

DRAFT

APPENDIX Q2: Key Considerations and Best Available Science for Protecting, Restoring, and Enhancing the Delta Ecosystem

Delta Plan Amendments

May 2020

For assistance interpreting the content of this document, please contact Delta Stewardship Council staff.

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Contents

List of Figures

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Purpose

The Sacramento-San Joaquin Delta Reform Act of 2009 (Delta Reform Act) set out two coequal goals for the Delta: 1) protecting, restoring, and enhancing the Sacramento-San Joaquin Delta and Suisun Marsh as the heart of a healthy estuary and wetland ecosystem; and 2) providing a more reliable water supply for California.[1] The Delta Reform Act requires that these coequal goals be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place (California Water Code section 85054).

Pursuant to the Delta Reform Act, the Delta Stewardship Council (Council) adopted the Delta Plan, a legally enforceable management framework for the Delta for achieving the coequal goals. The purpose of this appendix is to highlight key considerations and best available science for protecting, restoring, and enhancing the Delta ecosystem.

The Delta Reform Act requires the Delta Plan to include measures that promote all of the following characteristics of a healthy Delta ecosystem (California Water Code section 85302(c)):

1. Viable populations of native resident and migratory species;
2. Functional corridors for migratory species;
3. Diverse and biologically appropriate habitats and ecosystem processes;
4. Reduced threats and stresses on the Delta ecosystem; and
5. Conditions conducive to meeting or exceeding the goals in the existing species recovery plans and state and federal goals with respect to doubling salmon populations.

The Delta Reform Act also requires the Delta Plan to include the following subgoals and strategies for restoring a healthy ecosystem (California Water Code section 85302(e)):

1. Restore large areas of interconnected habitats within the Delta and its watershed by 2100;
2. Establish migratory corridors for fish, birds, and other animals along selected Delta river channels;
3. Promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm by invasive species;
4. Restore Delta flows and channels to support a healthy estuary and other ecosystems;

[1] The Sacramento-San Joaquin Delta and Suisun Marsh are referred to throughout the Delta Plan collectively as "the Delta," unless otherwise specified.

5. Improve water quality to meet drinking water, agriculture, and ecosystem long-term goals; and
6. Restore habitat necessary to avoid a net loss of migratory bird habitat and, where feasible, increase migratory bird habitat to promote viable populations of migratory birds.

The use of best available science is essential to ensuring that actions to protect, restore, and enhance the Delta ecosystem contribute to the subgoals and strategies for restoring a healthy Delta ecosystem, as defined by the Delta Reform Act. Delta Plan Policy **G P1(b)(3)** (23 CCR section 5002(b)(3)) requires covered actions to document use of best available science as relevant to the purpose and nature of the project. Criteria for best available science include relevance, inclusiveness, objectivity, transparency and openness, timeliness, and peer review. The regulatory definition of best available science is set forth in 23 CCR 5001(f) and can also be found in Appendix 1A of the Delta Plan.

This Appendix Q2 summarizes best available science as it relates to protecting, restoring, and enhancing the ecosystem, consistent with the policies and recommendations in Chapter 4 of the Delta Plan. It draws on the literature synthesized in the Council's paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* (2018a) which was subject to review and input by the Delta Independent Science Board (Delta ISB) and the public. The information contained in this appendix does not replace or supersede the documented use of best available science relevant to the purpose and nature of the project as required for all covered actions by policy GP 1(b)(3) (23 CCR section 5002(b)(3)).

Appropriate Elevation, Sea Level Rise, and Subsidence

Land elevation in the Delta and other tidal systems is a strong determinant of ecological patterns and outcomes because it affects how frequently and deeply an area may be inundated by river or tidal flows, and it is often defined in relation to tidal elevations (SFEI-ASC 2016). For example, tidal wetland vegetation occurs in the upper range of the tides; channels in tidal wetlands occur in the lower range of the tides; and riparian vegetation communities occur within river floodplains, above the regular reach of the tides. Terrestrial ecosystems generally do not exist below the lower range of tides unless they are not hydrologically connected (such is the case in Death Valley, which is more than 200 feet below sea level).

Land elevations are often, though not always, defined in relation to local tidal datums, which are standard reference elevations defined by a certain phase of the tide. Tidal water elevations are highly variable, fluctuating from low tide to high tide twice within a day, and also varying across days, months, and years depending on the gravitational pull of the moon and sun, and weather (NOAA 2000). For this reason, tidal reference elevations are generally characterized as an average of specific tidal heights over a period of time that accounts for natural variability. Common tidal datums used in this appendix are mean lower low water (MLLW), mean higher high water (MHHW), and mean tide level (MTL). MLLW is the average of the lower low water height of each tidal day; MHHW is the average of the higher high water height of each tidal day; MTL is the average of all observed water heights.

Human modifications to tidal wetland ecosystems, including levee construction and land reclamation, have caused a widespread decrease in land elevations to levels below MLLW. A decrease in land elevations relative to a starting condition is known as subsidence. Land reclamation exposes peat soils to air, causing oxidation and decomposition of the organic matter, and consequently, subsidence (Deverel et al. 2016). Levees prevent hydrologic connections and tidal inundation, which promotes further land subsidence. Exposing these subsided areas to tidal inundation, whether intentionally or via a levee breach, would result in open water habitat—as the land elevations have subsided too far below the tidal range to function as tidal wetland (Durand 2017).

The dominant farming practices on subsided islands in the Delta continue to expose peat soils to oxidation, causing ongoing subsidence. Subsidence can be halted by activities that saturate the soil, reducing the exposure of the soil to oxygen, and resulting in less decomposition of organic matter. Rice cultivation is an agricultural practice that halts subsidence, as it maintains land elevations at or near their starting condition. Some practices can also reverse subsidence, by creating or promoting accumulation of new soil layers. Examples of such practices include, but are not limited to, managed wetlands, placement of fill, and levee breaching to reestablish hydrological connections. Subsidence and subsidence reversal are both processes that change the elevation of land relative to tidal datums, and are therefore important considerations for actions to protect, restore, and enhance Delta ecosystems.

Another process that will change land elevations, relative to water levels and tidal datums, is sea level rise. Sea level rise is a change in average global sea level caused by a change in ocean volume. Local sea level rise can be greater or lesser than global sea level rise, because local sea levels are also affected by local land changes, ocean circulation, and changes to the earth’s gravitational field due to melting ice sheets. The California Ocean Protection Council recommends preparing for 2.4 to 10.2 feet of sea level rise at the Golden Gate Bridge by 2100 (OPC 2018). These guidelines are probabilistic projections from an average of relative sea level over the period of 1991-2009, and include recommendations tailored to several levels of risk aversion. Local sea level rise will increase levels of MLLW, MTL, and MHHW within Suisun Marsh and much of the Delta.

The Council’s synthesis paper *Climate Change and the Delta: A Synthesis* identified the expected impacts of sea level rise to tidal wetland ecosystems (Council 2018b). The locations, types and extents of tidal wetland patches in the Delta and Suisun Marsh will shift in response to increase in MHHW (Kirwin and Megonigal 2013, Goals Project Update 2015, Dettinger et al. 2016, SFEI-ASC 2016, CDFW 2017a as cited in Council 2018b). If tidal wetlands can accrete new material at pace with the rate of sea level rise, those patches may persist. If sea level rise accelerates beyond local accretion rates, wetland patches will lose elevation, and over time, may be permanently inundated and converted to aquatic ecosystems. The land that was previously at elevations within the tidal range will be submerged below it due to sea level rise.

Where upland space is available adjacent to tidal wetland patches, wetland vegetation can migrate to higher elevations in concert with, and in response to the increased mean tidal levels (Orr and Sheehan 2012, Dettinger et al. 2016). The band of unimpeded upland space that is expected to be within the future tidal range is called sea level rise accommodation space because it can accommodate processes like tidal wetland migration in response to sea level rise.

Sea level rise, like subsidence and subsidence reversal, therefore changes the existing relationship between land elevation and tidal elevations, and thus, the extent and distribution of ecosystem types. Because land elevation is a primary determinant of ecological outcomes, understanding and planning for changes to land elevation—relative to tidal elevations—should be factored into actions that protect, restore, and enhance Delta ecosystems.

In order to inform and support this understanding, the Council commissioned a detailed spatial analysis of future land and tidal elevations, accounting for current land elevations, local sea level rise projections, and variation in the tidal range within the Delta. Detailed methods used in this analysis are provided in Appendix Q1. The resulting elevation guidance map (Figure 1) illustrates five elevation bands that correspond to the dynamic relationship between land elevation, subsidence, and sea level rise:

- **Deep Subtidal Elevation Band**: in the Delta, land area that is located more than 8 feet below MLLW. In Suisun Marsh, land area that is located more than 4.5 feet below MLLW. Land in this elevation band is not capable of being restored to MTL without the addition of substantial fill given its existing subsided condition and projected local sea level rise.
- **Shallow Subtidal Elevation Band**: in the Delta, land area that is located between MLLW and 8 feet below MLLW. In Suisun Marsh, land area that is located between MLLW and 4.5 feet below MLLW. Land in this elevation band has an existing subsided condition that could potentially be restored to MTL through subsidence reversal activities.
- **Intertidal Elevation Band**: land area that is located between MLLW and MHHW. Land in this elevation band could potentially keep pace with local sea level rise, where it is hydrologically connected to tidal inundation.
- **Sea Level Rise Accommodation Band**: land area that is located between MHHW and 10 feet above MHHW. With sea level rise, land in this elevation band could fall within the future tidal range by 2100.

- **Upland Elevation Band:**[2] land area that is located at elevations higher than 10 feet above MHHW, and not within the Floodplain Elevation Band. Land in this elevation band is not expected to be impacted by sea level rise over the next century.
- **Floodplain Elevation Band**: lands above the Sea Level Rise Accommodation Band within the Yolo Bypass and the Lower Mokelumne-Cosumnes Rivers and lower San Joaquin River corridors.

These six elevation bands correspond to those specified in Appendix 4A. The elevation band illustrative map in Figure 1 is provided as a resource to inform the general locations of these elevation bands.

Successful actions to protect, restore, or enhance the Delta ecosystem will be implemented at elevations that can support project goals and where the benefits of the project will be sustainable; considering current elevations, anticipated sea level rise, and the potential for subsidence reversal. As discussed above, tidal wetland protection, restoration, and enhancement can only be successful long-term if implemented in areas that are within the tidal range, or likely to be within the tidal range in the future (such as the Intertidal Elevation Band and Sea Level Rise Accommodation Band).

Tidal wetland protection, restoration, and enhancement is not appropriate at elevations that are too far below MLLW to be capable of reaching the tidal range in the future; however, managed wetlands that are designed to promote subsidence reversal and carbon sequestration would be appropriate for lands at these elevations. Conversely, present-day elevations that *are* capable of reaching the tidal range in the future are not appropriate for activities that continue to cause subsidence because those activities could foreclose on the potential to reach MTL.

Other actions to protect, restore, or enhance the ecosystem are appropriate at elevations far below MLLW and well-above MHHW. For example, the Deep Subtidal Elevation Band is appropriate for agricultural practices that leave crop residues as feed that can contribute to the protection and recovery of certain special-status native resident and migratory birds. The Upland Elevation Band is appropriate for actions that protect, restore, or enhance oak woodland, grassland, and seasonal wetlands. The Floodplain Elevation Band is appropriate for actions that protect, restore, or enhance upland and lowland river floodplain ecosystems.

[2] Upland areas are not specified on the map, but they consist of land at elevations above the sea level rise accommodation band and outside of floodplain areas.

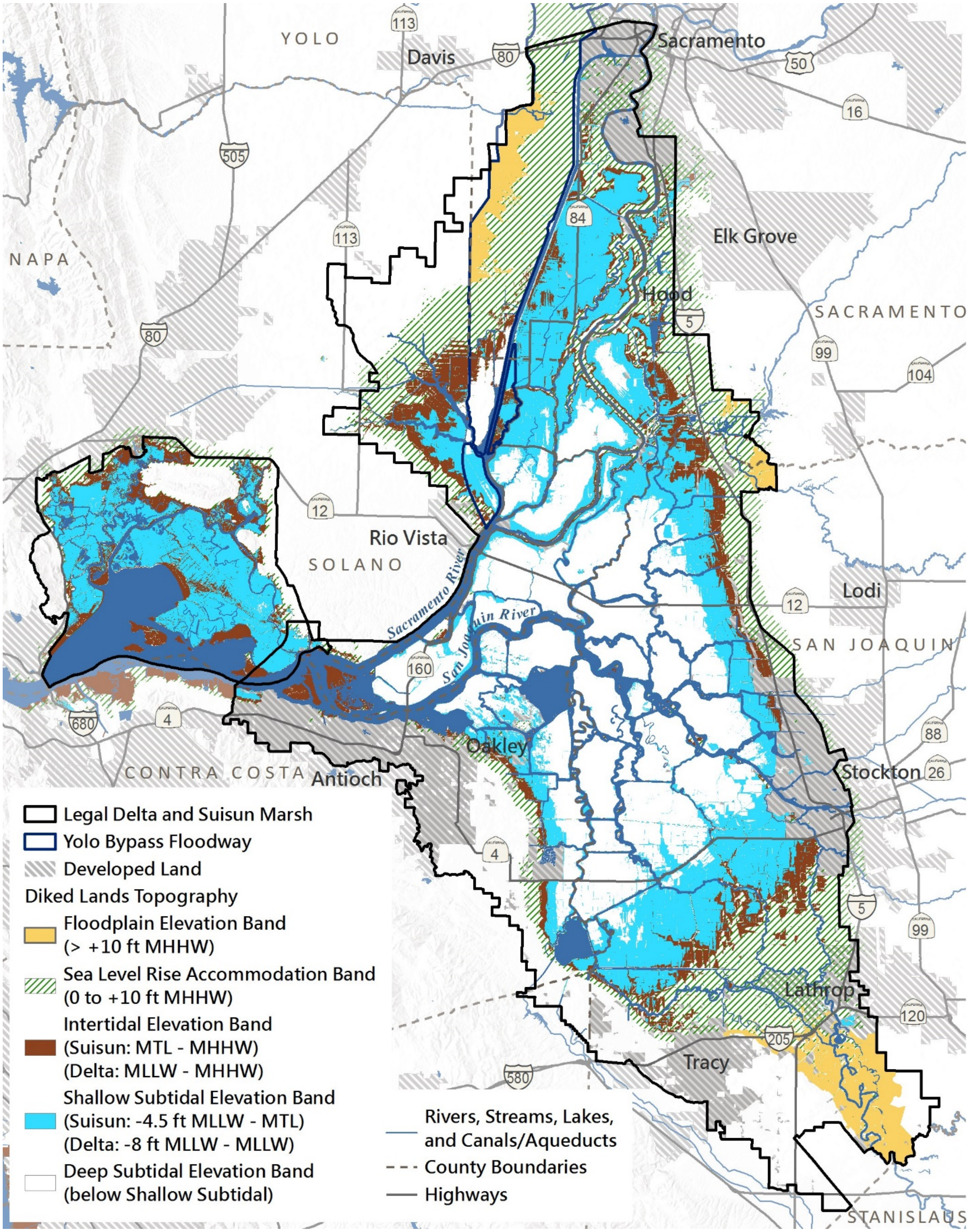

Figure 1. Elevation Band Illustrative Map

Figure 1. Elevation Band Illustrative Map (contd.)

Figure 1 is a map that illustrates Elevation Bands within the Delta.

The Floodplain Elevation Band is the least extensive among those shown in the map. Land areas within the Floodplain Elevation Band are concentrated as follows: on the western side of the Yolo Bypass; two small areas west of the City of Galt along the Cosumnes and Mokelumne Rivers; and a conical shaped area at the southeastern tip of the Delta, along the San Joaquin River, south of the City of Lathrop.

The Sea Level Rise Accommodation Band includes: a narrow strip of land at the northern boundary of Suisun Marsh, small patches of land at the eastern edge of Suisun Marsh; a wide swath of land at the western edge of Cache Slough that continues into much of Yolo Bypass; waterside levee area along the Sacramento River and adjacent channels and sloughs; a strip of land at the eastern boundary of the Delta along Highway 5, between Stockton and Sacramento; a wide swath of land north of Tracy and Lathrop at the base of the San Joaquin River floodplain; and a narrow strip of land extending from Tracy west to Clifton Court Forebay, and northwest to Oakley.

Existing tidal wetlands in Suisun Marsh and western Delta islands near Pittsburg are located in the Intertidal Elevation Band. Other concentrated land areas located within the Intertidal Elevation Band are within Cache Slough and in the south Delta. There are narrow strips of land located in the Intertidal Elevation Band at the edges of the Sea Level Rise Accommodation Band, extending along Highway 5 between Stockton and Sacramento, and from Tracy to Oakley. Scattered patches of land in the Intertidal Elevation Band are also present on Decker Island, Prospect Island, Merritt Island, Pearson District, McCormack Williamson Tract, and New Hope Tract.

The Shallow Subtidal and Deep Subtidal Elevation Bands are the most extensive. The Shallow Subtidal Elevation Band consists of: the majority of Suisun Marsh; the southeastern corner of Cache Slough; land between the Sacramento River Deep Water Ship Channel and the Sacramento River in the north Delta; the majority of the Pearson District; a strip of land along the eastern edge of the Delta, adjacent to and west of the Intertidal Elevation Band; land south of Highway 4 and adjacent to the Intertidal Elevation Band, in the south Delta; and a narrow strip of land running north from Clifton Court Forebay to Oakley.

The Deep Subtidal Elevation Band consists primarily of land areas on islands in the central and western Delta, from Sherman Island in the west to Rindge Tract in the east, and from Victoria Island in the south to Liberty and Grand Islands in the north.

Alternative formats of this map are available upon request.

Ecosystem Function

The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* provides a review of approaches to ecosystem restoration, and it identifies key ecosystem properties that promote resilience (Council 2018a). Given that Delta ecosystems are expected to be further stressed by a rapidly changing climate, reestablishing ecological resilience is an important restoration target (Ibid, p. 19). Delta Plan Chapter 4, *Protect, Restore, and Enhance the Delta Ecosystem*, translates these ecosystem properties into priority attributes for actions that include protection, restoration, and enhancement of the Delta ecosystem, to ensure that actions contribute to restoring ecosystem function. These priority attributes are:

1. Restore Hydrological, Geomorphic, and Biological Processes
2. Be Large-Scale
3. Improve Connectivity
4. Increase Native Vegetation Cover
5. Contribute to the Recovery of Special-Status Species

Hydrological, Geomorphic, and Biological Processes

The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified the reestablishment of hydrological, geomorphic, and biological processes—also termed *process-based restoration*—as key to improving vegetation community composition and structure, and habitat conditions for sensitive specialist species (Council 2018a, p. 13). Process-based restoration is also essential to creating dynamic and variable conditions like those of the pre-Columbian Delta (see Delta Plan Chapter 4, section "The Delta's Historical Ecology," pp. 4-5).

Hydrological processes are physical flows and cycles exhibited by water, including streamflow, flooding, tidal action, percolation, and subsurface flow. Geomorphic processes are the physical forces that shape and form the surface of the earth including sediment erosion and deposition, river meander migration, and channel formation. Biological processes are processes exhibited by the living components of an ecosystem such as nutrient cycling, primary production, vegetation and wildlife recruitment and growth, predation, and evolution. Process-based restoration is restoration that aims to reestablish the rates and magnitudes of these processes that can sustain dynamic ecosystems (Beechie et al. 2010, Greco 2013, Wiens et al. 2016).

The hydrological, geomorphic, and/or biological processes that a project could restore, vary based on the ecosystem type. For example, within willow thicket, willow riparian scrub or shrub, and valley foothill riparian ecosystems, the creation of unrestrained (natural) stream channels may reestablish hydrological processes that allow cut-bank and point-bar formation, meander migration, and the development of shaded riverine aquatic habitats (DeHaven 1998). To restore seasonal wetlands, water input from precipitation, runoff, groundwater, or subsurface flow can reestablish hydrological processes that support temporary or seasonal wetting (Calhoun et al. 2014).

Reestablishment of geomorphic processes such as sediment delivery, scour, and accretion can restore tidal wetlands or willow thicket in upland and lowland river floodplains. Additionally, reestablishing biological processes, such as native vegetation recruitment, growth, and succession can restore a variety of habitats, including wet meadow, alkali seasonal wetland complex, vernal pool complex, upland and lowland river floodplain, and emergent wetland.

Restoring hydrological, geomorphic, and biological processes addresses the root causes of ecosystem degradation and promotes self-sustaining ecosystems that require less active management or corrective action (Beechie et al. 2010). Process-based restoration also promotes resilience to changing conditions, such as sea level rise and changes in precipitation due to climate change. A process-based approach to restoration will lead to the development of a healthy Delta ecosystem, which includes diverse and biologically appropriate habitats and ecosystem processes (California Water Code section 85302(c)(3)).

Scale

The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified spatial and temporal scales as essential properties that affect ecosystem resilience and the attainment of subgoals of the Delta Reform Act (Council 2018a, p. 22). Critical biotic interactions and physical processes depend on appropriate levels of diversity (Larkin et al. 2016) made possible by large-scale projects. Large intact core areas of habitat are important for reducing human disturbance and facilitating the ecological interactions that are important to species persistence (Soule and Terborgh 1999).

The hydrological, geomorphic, and biological processes described above operate at various spatial scales across different ecosystem types, requiring consideration in siting and design of covered actions (Palmer et al. 2016b, SFEI-ASC 2016). For example, emergent wetlands—which include tidal and nontidal wetlands with nonwoody vegetation—require a patch size equal to, or greater than, 200 hectares (500 acres) to support the formation of long, multiorder channel networks (Whipple et al. 2012, SFEI-ASC 2016). The physical complexity and length of these channel networks create hydrologic conditions that support chemical and biological processes, including variation in environmental water quality, vegetation, and food-web dynamics (Whipple et al. 2012, SFEI-ASC 2016, Cloern et. al. 2016). The branching channel networks provide physical habitat and food resources required by aquatic species, including many special-status fish species, for refuge, reproduction, foraging, and feeding. These conditions also influence the prevalence of nonnative invasive species which have deleterious effects on native aquatic species (Nobriga et al. 2005). Therefore, restoration of large emergent wetlands with high ecological function must occur in order to fulfill the subgoals of the Delta Reform Act, to reduce the risk of harm from invasive species (California Water Code section 85302(e)(3)), and to restore channels to support a healthy estuary (California Water Code section 85302(e)(4)), among other subgoals and strategies.

In contrast, river geomorphic processes operate at the site (erosion), reach (meander/braiding), and watershed (watershed zone) scale (Schumm 1977). For upland and lowland river floodplains—including willow thicket, willow riparian scrub or shrub, and valley foothill riparian—river corridor restoration that reestablishes floodplain inundation and stream channel dynamics over a distance orthogonal to the channel (i.e., floodplain width) that is equal to, or greater than, the mean of six reach-specific bankfull channel widths is required to support riverine hydrological, geomorphic, and biological functions (Larsen et al. 2006). In some regions, topographic features such as the presence of natural levees may constrain this width interval (SFEI-ASC 2014).

Seasonal wetlands (including vernal pool complexes, alkali seasonal wetland complexes, and wet meadows) require patch sizes of at least 40 to 100 acres to optimally support the life history needs of sensitive species (ICF 2013, Johnson et al. 2010). Riparian vegetation in upland and lowland river floodplains—including willow thicket, willow riparian scrub or shrub, and valley foothill riparian—need to be greater than 200 acres (Laymon and Halterman 1989, SFEI-ASC 2014), and contiguous oak woodlands and grasslands need to be greater than 40 to 100 acres (ICF 2013, Johnson et al. 2010). To stabilize interior dune vegetation, sand mound features need to be greater than 1.5 acres—the smallest size that occurred in the historic Delta (Whipple et al. 2012).

Actions that restore the ecosystem at large spatial scales will increase the likelihood of creating and supporting natural systems capable of sustaining desired functions through uncertain future environmental conditions (Peterson et al. 1998, SFEI-ASC 2016).

Connectivity

The Delta Reform Act specifies that the Delta Plan must include subgoals and strategies to restore large areas of *interconnected* [emphasis added] habitats within the Delta and its watershed by 2100 (California Water Code section 85302(e)(1)). The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified connectivity as essential for ecosystem resilience (Council 2018a, p. 20).

Reestablishing connectivity is essential for the long-term persistence of native species in the Delta. Issues of connectivity include restoration of physical (e.g., hydrology and sediment transport) and biological (e.g., movement of vegetation that propagates, fish, and wildlife) connections. This section provides descriptions for different aspects of connectivity that should be considered in restoration actions.

Since watersheds are three-dimensional hydrological systems, restoring hydrological connectivity requires consideration of longitudinal (between upper watersheds to the San Francisco Bay), lateral (between channels and floodplains), and vertical (between surface and groundwater) connections. Reestablishing longitudinal connectivity from the upper watersheds throughout the Delta to the Bay is critical to many species that reside or migrate through the Delta. Remediation of fish passage barriers—including dams, diversions and other impediments, and improvements of poor habitat conditions—can improve connectivity for fish movement. Fish passage improvement actions would reduce stress and mortality in lower parts of the system, reconnecting fish with cold water habitats above dams, thus reducing the need to manage spawning conditions with flows on specific watersheds (Moyle et al. 2008).

In the Delta, restoration of lateral connections between channels and floodplains, and vertical connections between surface and groundwater, are other facets of connectivity that are essential to ecosystem function and resilience. Such connections are necessary for tidal wetland and floodplain inundation; sediment and nutrient delivery and export; disturbance processes; trophic processes; and the establishment, growth, and succession of native vegetation communities. It has been well studied that increased lateral connections improve access to food resources for fish, nutrient and carbon cycling, vegetation community patch dynamics, and species-habitat interactions (Vannote et al. 1980, Naiman et al. 1988, Ward 1989, Junk et al. 1989, Poff et al. 1997, Naiman and Decamps 1997, West and Zedler 2000).

Another critical aspect of connectivity is the distribution, extent, and proximity of different ecosystem and habitat types. The distance between patches of similar ecosystems determines the degree of animal movement, energy flow, and gene flow, and varies within and across ecosystem types. The distance between individual vernal pools is measured in meters, while the distance between pool complexes may be in kilometers. The maximum distance between patches should incorporate species' movement capabilities, resource needs, population dynamics, and gene flow (e.g., distance between tidal wetlands should be less than 15 km for salmon rearing, and between 0.2-5 km for wetland wildlife movement). Many species need different ecosystem types in their life histories. Minimizing distances between patches of different ecosystem types can increase survival. For example, Chinook salmon require a sequence of hydrologically connected habitats to migrate, spawn, rear, and mature; including rivers, seasonal floodplains and tidal marsh habitat.

Improved connectivity will also increase ecosystem resilience and adaptive potential in the face of a rapidly changing climate (Naiman et al. 1993, Seavy et al. 2009, SFEI-ASC 2016). Connections between tidally inundated habitats and adjacent uplands with suitable elevations can support landward wetland migration as sea level rises. Wetland migration within the Delta and Suisun Marsh was historically common, but is currently limited by the presence of levees, roads, railways, and other obstacles.

In the long-term, restoring connections between aquatic and wetland habitats, such as between channels and marsh plains, and connectivity to spawning habitats are of the utmost importance for species' viability and genetic resilience. The various aspects of connectivity are crucial to the ability of riparian and wetland systems to support biodiversity.

Native Vegetation Cover

The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified the positive effects that native vegetation communities have on ecosystem processes (Council 2018a, p. 31, 39). Increasing the extent and variety of native vegetation cover can promote ecological resilience and enhance native biodiversity by providing a range of habitat options for species, thus expanding the types and numbers of species that a landscape can support. This section identifies the characteristics of different Delta ecosystems and their associated native vegetation communities.

The classification of ecosystems and vegetation communities draws primarily from the San Francisco Estuary Institute-Aquatic Science Center’s (SFEI-ASC) habitat types (2014) and the Vegetation Classification and Mapping Program (VegCAMP). VegCAMP is the California component of the National Vegetation Classification system, maintained by the California Department of Fish and Wildlife in collaboration with other agencies and organizations. Delta Plan Chapter 4, *Protect, Restore, and Enhance the Delta Ecosystem*, and its appendices, utilize the 2018 Delta Fine Scale VegCAMP Vegetation Map and 2015 Suisun Marsh Fine Scale VegCAMP Vegetation Map to characterize native vegetation communities in different Delta ecosystem types.

Freshwater emergent wetlands in the Delta include tidal and nontidal wetland ecosystems. Tidal freshwater wetlands are wetted or inundated by spring tides at low river stages or by lower tidal levels at higher river stages. These ecosystems are characterized as being permanently saturated, having a high water table, and are typically dominated by emergent vegetation. Woody vegetation (e.g., willows) may be a significant component for some areas, particularly the western-central Delta. Non-tidal wetland ecosystems in the Delta occupy upstream floodplain positions above tidal influence. These ecosystems are temporarily to permanently flooded, permanently saturated, and are dominated by emergent vegetation (SFEI-ASC 2014).

Upland and lowland river floodplain habitats in the Delta include willow thicket, willow scrub or shrub, and valley foothill riparian. Willow thicket are characterized as perennially wet, dominated by woody vegetation, and generally located at the *sinks* of major creeks or rivers as they exit alluvial fans into the valley floor. Emergent vegetation may also be a significant vegetation component in these habitats (SFEI-ASC 2014). Willow scrub or shrub habitats are riparian vegetation habitats dominated by scrubs or shrubs with few or no tall trees. This ecosystem type generally occupies long, relatively narrow corridors of lower natural levees along rivers and streams. Valley foothill riparian habitats are mature forests that are usually associated with a dense understory and mixed canopy, including sycamore, oaks, willows, and other trees. Historically, this ecosystem type occupied the supratidal natural levees of large rivers that were occasionally flooded (SFEI-ASC 2014).

Seasonal wetlands in the Delta include wet meadows, vernal pool complexes, and alkali seasonal wetland complexes. These three ecosystems often comprise the upland edge of perennial wetlands (SFEI-ASC 2014) and they are seasonally or temporally flooded. While all three occur on poorly drained soils, they differ by soil conditions. Wet meadow ecosystems are characterized by clay-rich soils and associated with herbaceous plant communities. Vernal pool complexes are characterized by a relatively impermeable subsurface soil layer and distinctive vernal pool flora. Alkali seasonal wetland complexes are characterized by clay-rich soils with a high residual salt content and associated with herbaceous or scrub communities.

Upland ecosystems in the Delta include stabilized interior dune vegetation, grassland, and oak woodland. Stabilized interior dune vegetation is dominated by shrub species, with some locations also supporting live oaks on the more stabilized dunes with more well-developed soil profiles. Grasslands are low herbaceous communities occupying well-drained soils and are composed of native forbs and annual and perennial grasses, usually devoid of trees. Oak woodlands are oak-dominated communities with sparse to dense cover (10-65 percent) and an herbaceous understory (SFEI-ASC 2014).

Restoration of the Delta ecosystem will require increasing the native vegetation cover, and restoring the underlying processes that support recruitment, disturbance regimes, and community succession (as described under the Hydrological, Geomorphic, and Biological Processes sections of this document). As previously discussed in the Scale section, these underlying processes operate at various spatial scales across different ecosystem types. Therefore, the extent of native vegetation cover should align with the scale at which ecosystem processes can support the vegetation communities to be self-sustaining. Accounting for the site access, infrastructure, and facilities that are often needed for monitoring and maintenance of restoration projects, it is reasonable to expect that native vegetation should cover at least 75 percent of the area over which ecosystem processes are restored.

Special-Status Species

The Delta Reform Act is clear that protecting, restoring, and enhancing the Delta ecosystem means protecting and recovering special-status species. The Delta Reform Act requires the Delta Plan to include measures that promote viable populations of native resident and migratory species; conditions conducive to meeting or exceeding the goals in the existing species recovery plans (California Water Code section 85302(c)(1) and (5)); and to promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm from invasive species, among other subgoals and strategies (California Water Code section 85302(e)).

Special-status species are a species or subspecies of animal or plant, or a variety of a particular plant, that is endangered, rare, or threatened as defined by Title 14 of the California Code of Regulations sec. 15380, or that is designated as a Species of Special Concern by the California Department of Fish and Wildlife. At least 35 native plant species, and 86 fish and wildlife species in the Delta are imperiled by human activities (Appendix Q4) and are at varying risks of either local or outright extinction. Habitat loss and degradation, and the resulting impacts on food-web dynamics, have been a major cause of the statuses and listings of these species. Recovering these species is essential to preventing the loss of the unique biodiversity in the Delta.

Different species and communities are supported by different ecosystem types. For example, managed wetlands can protect and support the recovery of native migratory bird species, such as sandhill cranes (Appendix Q4). In contrast, the California black rail requires emergent wetland with gently grading slopes and upland refugia (see Appendix Q4), and is not supported by managed wetland projects. Therefore, actions that protect, restore, or enhance ecosystems can contribute to the recovery of different special-status species and ecological function, depending on the type and scale of the action (Suding 2011, Palmer et al. 2016).

Human Context for Protecting, Restoring, and Enhancing the Ecosystem

The Delta Reform Act requires that the coequal goals be achieved, "in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place" (California Water Code section 85054). The Delta is not a blank canvas, but rather a region with existing agricultural and urban land uses, diverse cultural values, and human needs. Literature on ecosystem restoration increasingly affirms the need to consider human needs and benefits from restored lands (Council 2018a, Suding et al. 2015). Covered actions must leverage best available science to successfully integrate into this existing human context.

Existing Land Uses

Chapter 5 of the Delta Plan, "Protect and Enhance the Unique Cultural, Recreational, Natural Resource, and Agricultural Values of the California Delta as an Evolving Place," describes the vision for the Delta as an evolving place and identifies regulatory policies and recommendations to achieve that vision. Delta Plan Policy **DP P2** (23 CCR section 5011) requires that ecosystem restoration (and other types of projects and improvements) avoid or reduce conflicts with existing or planned future land uses, when feasible, among other requirements.

The Delta Reform Act's requirement to achieve the coequal goals in a manner that protects and enhances the unique values of the Delta as a Place recognizes the potential conflicts between certain covered actions and existing land uses. Consequently, it is important that covered actions that include protection, enhancement, or restoration of the ecosystem are implemented in a manner that reduces such conflicts. One way to avoid or reduce conflicts with existing land uses is through proactive engagement and coordination with adjacent and nearby landowners and users, starting early in the planning stages of a project. Coordination with neighboring landowners and local communities helps covered actions avoid unintended consequences like trespassing, property damage, crop damage, wildlife hazards to aircraft, or damage to the ecosystem. Consequently, the Delta Plan recommends that restoration project managers use the Department of Water Resources' Good Neighbor Checklist to avoid or reduce conflicts with existing uses.

The California Department of Water Resources developed the Good Neighbor Checklist to support proactive communication with nearby landowners. The checklist is based on a discussion paper that was developed in consultation with local landowners and other stakeholders, to identify strategies for addressing priority conflicts and unintended consequences (DWR 2019). The checklist provides a framework for covered actions to avoid or reduce conflicts with existing uses. All covered actions are unique, and not all of the checklist questions and strategies will apply in all cases.

Social Benefits

Proper planning, implementation and management of covered actions that include protection, restoration, and enhancement of the ecosystem, can ensure that actions do more than simply avoid conflict or harm. Actions can also provide social benefits that enhance the cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

Social benefits are positive values that are derived by individuals, communities, or society at-large. The Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* identified a variety of social benefits that can be derived from actions to protect, restore, and enhance the ecosystem (Council 2018a). The synthesis paper also identified methods to assess and value those benefits. In the context of Chapter 4 of the Delta Plan (Protect, Restore, and Enhance the Ecosystem), social benefits are indirect cultural, recreational, natural resource, and agricultural benefits that individuals or groups of people derive from the protection, restoration, or enhancement of the ecosystem. These categories were identified to correspond to the cultural, recreational, natural resource, and agricultural values of the Delta as identified in the Delta Reform Act (California Water Code section 85054).

The benefits described within each category are not a comprehensive list. The specific benefits discussed in this section have a well-established scientific basis, and a direct connection to restoring, enhancing, and protecting the Delta ecosystem. However, actions that restore, enhance, and protect the Delta ecosystem could result in social benefits beyond those discussed here.

Cultural Benefits

Cultural benefits are a type of social benefit derived by individuals and/or communities with distinct cultural ties to the ecosystems, plants, fish, and wildlife of the Delta. Cultural benefits may include, but are not limited to, support of ecocultural resources, human health and well-being, and environmental justice. These types of cultural benefits were identified in the Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* as social benefits that can be derived from actions to protect, restore, and enhance the ecosystem (Council 2018a, p. 10).

Ecocultural resources are resources needed to maintain the nature-dependent components of culture (Pretty 2011), such as plants, fish, and wildlife that hold special cultural and/or spiritual value to American Indian tribes. For example, salmon are "integral to the customs, religion, culture, and economy of the Hoopa Valley Tribe and its members" (Hoopa Valley Tribal Council 2012). Tribal engagement during project planning and management can help proponents identify, assess, and protect resources of eco-cultural importance (Hankins 2018). For example, the Miwok have identified specific species of eco-cultural importance in the Delta, including Delta smelt, longfin smelt, winter-run Chinook salmon, spring-run Chinook salmon, steelhead, Sacramento splittail, green sturgeon, white sturgeon, Pacific lamprey, river lamprey, riparian brush rabbit, San Joaquin kit fox, Ridgway's Rail, California Black Rail, California Clapper Rail, Greater Sandhill Crane, Swainson's Hawk, Western Burrowing Owl, Yellow-breasted Chat, western pond turtle, California red-legged frog, California tiger salamander, California linderiella, conservancy fairy shrimp, longhorn fairy shrimp, vernal pool fairy shrimp, vernal pool tadpole shrimp, brittlescale, and San Joaquin spearscale (Hankins 2018).

Human health and well-being is a condition of bodily comfort and happiness that is free from sickness or suffering (King et al. 2009, Roche and Rolley 2011). The Delta Reform Act finds that, "to promote the public safety, health, and welfare… it is necessary to protect and enhance the ecosystem of the Delta" (California Water Code section 85022(c)) and identifies a fundamental goal for land-use management in the Delta to "improve water quality to protect human health" (California Water Code section 85022((d)). These findings are supported by scientific literature. Human health and well-being have been linked to environmental quality and access to natural systems (Bowler et al. 2010, MacKerron and Mourato 2013). Exposure to nature has been demonstrated to improve wellness (Roche and Rolley 2011), and health outcomes have been tied to environmental quality (King et al. 2009). Covered actions that improve environmental quality (e.g., air quality, water quality) can improve health (Schwarzenbach et al. 2010, WHO 2013).

Research on multiple restoration projects in the United States suggests that restoration can also help communities alleviate environmental injustices (Pastor 2007). Warlenius et al. (2015) argue that significant environmental degradation harms communities and therefore produces an *ecological debt*. Ecological debt is the concept that the exploitation or degradation of a natural resource creates a responsibility to repay that "debt" to human communities harmed by the degradation. Ecosystem restoration is one method for achieving environmental justice through repaying that ecological debt. One way to address environmental justice concerns is for proponents of covered actions to engage and co-plan with disadvantaged communities, provide access for safe subsistence fishing, and to improve environmental conditions for at-risk groups (Shilling et al. 2009, Sze et al. 2009).

Recreational Benefits

Recreation benefits are a category of social benefits that are derived by individuals that recreate in the Delta, and the business operations and communities that such recreation supports. These types of recreational benefits were identified in the Council's synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* (Council 2018a, p. 8).

The Delta Reform Act identifies the goal to maximize public access to Delta resources and maximize public recreational opportunities in the Delta (California Water Code section 85022(d)). However, at present, much of the restoration land in the Delta is hard to access and/or off-limits to the public (Milligan and Kraus-Polk 2016). Covered actions can address this need by planning for human use, such as including features that encourage and provide access to land for exercise and relaxation.

Covered actions can provide amenities that support the long-term operations and maintenance of the asset, in addition to recreational uses. Boat ramps can be jointly used by monitoring staff and contractors, as well as by recreational boaters and those who fish. Parking and restroom facilities can be jointly used by land-management staff as well as individuals who recreate in the Delta. Anticipating and planning for human uses, including unsanctioned uses, of restoration sites will improve project outcomes (Milligan and Kraus-Polk 2016).

Not all covered actions will be appropriate for public access and recreation; hence the Delta Plan does not require that access be provided. Indeed, the Delta Reform Act notes that public access and recreational opportunities should be “consistent with sound resources conservation principles and constitutionally protected rights of private property owners” (California Water Code section 85022(d)).

Covered actions that contribute to the recovery of salmon and sturgeon populations, and that support viable populations of native resident and migratory birds, will promote a healthy Delta ecosystem (California Water Code section 85302(c)), while also indirectly benefitting recreational fishing, bird-watching, and wildlife observation. Delta community members identify water, waterways, wildlife, bird-watching, and exploring as among the best qualities of the Delta (AugustineIdeas 2015). These results indicate the centrality of the Delta ecosystem to attracting tourists into the region and meeting their expectations. Protecting, restoring, and enhancing the Delta ecosystem can help improve conditions for recreation in the Delta. Past research on recreation confirms that including tourism as part of restoration planning can help drive restoration on the landscape and benefit the tourism industry (Blangy and Mehta 2006).

Natural Resource Benefits

Natural resource benefits are a category of social benefits that are derived from ecosystem processes, goods, and services. Ecosystem services are the economic benefits that society derives from ecosystem processes, such as soil formation, water storage and regulation, climate regulation, and others (Constanza et al. 1997, Turner and Daily 2008, Postel and Carpenter 1997). These types of natural resource benefits were identified in the Delta Stewardship Council’s synthesis paper *Towards the Protection, Restoration, and Enhancement of the Delta Ecosystem* (Council 2018, pp. 6-9).

Cooperative ecosystem and resource management can maximize these benefits (Madani and Lund 2011). For example, maximizing natural resource benefits could mean managing Delta fisheries in a way that reduces risks to human health (Shilling et al. 2010), or restoring wetlands to provide flood control benefits and improve water quality (Mitsche and Gosselink 2000). Many ecosystem processes include services upon which all humans depend, and it behooves resource managers to find ways to incorporate these natural resource benefits into projects, where possible.

Agricultural Benefits

Agricultural benefits are a category of social benefits that are derived from agricultural operations in the Delta, and the individuals and communities that those operations support. Covered actions can support agricultural food production (Gonthier et al. 2014, Phalan et al. 2011). For example, protection, restoration, or enhancement of natural communities that support invertebrates and birds can provide pollination and/or natural pest control for surrounding agriculture (Tscharntke et al. 2005, Potts et al. 2010, Garibaldi et al. 2014).

A variety of covered actions can reduce flood risk for agricultural businesses and landowners. Tidal wetlands absorb tidal energy, so protecting or restoring tidal wetlands can attenuate tides further inland (Mitsche and Gosselink 2000). Setback levees can create more space in river and stream channels, reducing pressure on levees, increasing flood system capacity, and reducing velocity and erosion (USACE 2017). The Yolo Bypass is an example of a restoration project, which is managed for flood control, agriculture, and ecosystems (Sommer et al. 2001).

Subsidence reversal is another opportunity to reduce flood risk for agricultural operations in the Delta. Subsidence in the Delta is driven by the oxidation of the peat soils on reclaimed islands, increasing systemic risk of levee failure (Mount and Twiss 2005). Subsidence reversal is a process that halts soil oxidation and accumulates new soil material, in order to increase land elevations relative to a starting condition in which land elevations are below mean sea level. Over time, subsidence reversal can raise land elevations and reduce the risk of levee failure (Bates and Lund 2013).

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Appendix C
Attachment C-3.4
Non-substantive Revisions to Proposed Appendix Q2. Key Considerations and Best Available Science for Protecting, Restoring, and Enhancing the Delta Ecosystem Since May 2020

Appendix C
Attachment C-3.4

Non-substantive Revisions since May 2020 to Proposed Delta Appendix Q2. Key Considerations and Best Available Science for Protecting, Restoring, and Enhancing the Delta Ecosystem

Page Q2-14, end of third paragraph

Consequently, the Delta Plan recommends that restoration project**s** ~~managers~~ use the ~~Department of Water Resources’~~ Good Neighbor Checklist to avoid or reduce conflicts with existing uses.

Page Q2-14-15, beginning of fourth paragraph

~~The California Department of Water Resources developed the Good Neighbor Checklist to support proactive communication with nearby landowners. The checklist is based on a discussion paper that was developed in consultation with local landowners and other stakeholders, to identify strategies for addressing priority conflicts and unintended consequences (DWR 2019).~~ The **Good Neighbor** **C**~~c~~hecklist provides a framework for covered actions to avoid or reduce conflicts with existing uses. All covered actions are unique, and not all of the checklist questions and strategies will apply in all cases.

Page Q2-15, under a new header level 3 under first paragraph

Good Neighbor Checklist

Habitat restoration projects have many benefits, but can also affect neighboring properties, agriculture, infrastructure and water resources. Inclusion of Good Neighbor considerations into habitat restoration project planning can support agricultural communities, reinforce the benefits of conservation partnerships, reduce conflict and project delays, and help achieve sustainable conservation. Habitat restoration project planners and managers can use the following checklist to help ensure that restoration projects are planned and designed to avoid or reduce conflicts with existing neighboring land uses.

Some of the checklist items are also considered in California Environmental Quality Act (CEQA) and regulatory review processes. The purpose of the checklist is to encourage early conversations and coordination with neighboring

interests, and it does not substitute for any other process. Good Neighbor Restoration Projects:

Siting and Planning

- **Is the project sited on public or conservation-entity owned lands, or where private property is required, has there been engagement to find willing sellers?**
- **If there are existing agricultural or conservation easements, has thought been given to how to incorporate or avoid conflicts with them?**
- **Is the project sited to avoid fragmenting existing farms?**
- **Have neighbors and stakeholders been included in the early planning stage?**
- **Will the project potentially disturb utilities, roads, bridges, or other infrastructure that serve local uses? If so, are those uses taken into account during project planning?**
- **Is the project designed to avoid interfering with other beneficial water uses (e.g., existing water diversions, boating, fishing, and recreation)?**
- **Will the project design avoid or reduce damage to nearby drainage, irrigation, and flood control facilities (e.g., levees) during construction and operation and avoid conflicting management practices?**
- **Has the project considered buffers where restoration lands could potentially interfere with surrounding agricultural lands or where agricultural lands could potentially interfere with restoration lands?**
- **As a result of the project, are special status species on the project site expected to increase markedly in abundance, and potentially move from the site to neighboring lands or waterways? If so, has coordination on safe harbor or other protections for neighboring land and water uses been considered?**
- **Is the project designed so that any new public access is compatible with, would benefit, and would avoid or reduce conflict with, local businesses, landowners and residents?**

Construction, Operation and Maintenance

- **Is the project designed to avoid or reduce project dust, traffic, vibration, noise, and lighting impacts?**
- **Is the project designed to minimize project traffic during commute and harvest periods?**
- **Has the project considered utilizing invasive species protection plans, including potential long-term commitments or funding to:**
    - **Protect against proliferation of mosquitos to protect against arboviruses, which can lead to injury and mortality of wildlife and humans?**
    - **Monitor and treat terrestrial and aquatic weeds and set specific triggers for action?**

- **Has the project considered monitoring and mitigating project-related changes to local water quality and quantity to:**
  - **Protect beneficial water uses from harmful algal blooms, nitrates, phosphorous, and methylmercury?**
  - **Avoid drainage, seepage or changes in the water table that impair neighboring agricultural or other activities?**
- **Does the project consider, as applicable, mitigation for conversion of productive agricultural land in the form of conservation easements, or other measures to enhance local agricultural productivity?**
- **Does the project have an operation and maintenance plan that includes, as applicable, the ability to maintain site security, prevent trespass, manage any publicly accessible areas, and control flooding and weeds?**

Accessible Community Interface

- **Does the project provide for an Ombudsman Office or other means to:**
  - **Facilitate stakeholders and affected landowners and local agency discussions regarding offsite impacts and options to address them?**
  - **Provide a way to discuss resolution of disputes prior to resorting to the Government Claims Act or other legal claims processes?**
  - **Provide regular project updates to the affected public?**

Background and References for Good Neighbor Checklist

In 2020, a small group of Delta stakeholders representing reclamation districts, landowners and Delta counties approached the Department of Water Resources (DWR) to request that DWR work with them to update the Good Neighbor Checklist prepared in 2014 as part of the Agriculture and Land Stewardship Framework. Over the course of a few meetings, this updated draft checklist was created and later submitted to the Delta Stewardship Council for inclusion as an exhibit to ER Recommendation "B" in the Ecosystem Amendment. Representatives from Solano and Yolo Counties, the Delta Protection Commission, Delta Conservancy and DWR commented on the updated checklist, which built on the work of the key references listed below.

This information was transmitted to Council staff via email from Osha R. Meserve, *Soluri Meserve* on April 7, 2021.

Delta Conservancy. 2019. Delta Public Lands Strategy: A Guide for Conservation and Sustainability Across the West, Central, and Northeast Delta. Available at: http://deltaconservancy.ca.gov/wpcontent/uploads/2019/01/Delta_Public_Lands_Strategy_Final_1-22-19.pdf

Delta Stewardship Council. 2020. Delta Plan Chapter 4 - Protect, Restore, and Enhance the Delta Ecosystem – May 2020 Draft Ecosystem Amendment. Available at: https://deltacouncil.ca.gov/pdf/delta-plan/2020-04-15-draft-ch-04.pdf

Department of Fish and Wildlife (CDFW). 2018. Delta Conservation Framework – A Delta in Common. Available at: https://www.wildlife.ca.gov/Conservation/Watersheds/DCF

Department of Water Resources (DWR). 2019. Agricultural and Land Stewardship Framework and Strategies. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2013/Other/Agriculture-and-Land-Stewarship-Framework-and-Strategies.pdf

Page Q2-16, end of first paragraph

Traditional ecological knowledge (TEK) and local ecological knowledge (LEK) may also provide a basis for designing, operating, and managing projects to provide natural resource and cultural benefits (Charnley et al. 2017). TEK and LEK refer to the knowledge, practice, and belief concerning living beings (human and non-human) and the relationships between them, and is gained through multigenerational observation of and interaction with a specific place (Kimmerer 2012; Charnley et al. 2017).

Page Q2-18, second paragraph

Setback levees can create more space in river and stream channels, reducing pressure on levees, increasing flood system capacity, and reducing velocity and erosion (~~USACE 2017~~**Smith et al. 2017**).

Page Q2-19, after CDFW (2017)

Charnley, S., C. Carothers, T. Satterfield, A. Levine, M. Poe, K. Norman, J. Donatuto, et al. 2017. Evaluating the best available social science for natural resource management decision-making. *Environmental Science & Policy* 73: 80-88.

Page Q2-20, first entry under Department of Water Resources (DWR)

~~Department of Water Resources (DWR). 2019. Agriculture and Land Stewardship Framework. Available at: https://water.ca.gov/programs/california-waterplan/water-resource-management-strategies/%20agriculture-and-landstewardship-framework~~

Page Q2-20, second entry under Department of Water Resources (DWR)

~~_____~~**Department of Water Resources (DWR)**. 2017. Seamless DEM. Updated 20171016 by Karen Tolentino, DWR DFM Delta Levees Branch.

Page Q2-20, third entry under Department of Water Resources (DWR)

~~_____. 2014. Good Neighbor Checklist (as developed in 2014)~~

Page Q2-21, after Junk et al. 1989

Kimmerer, R.W. 2002. Weaving traditional ecological knowledge into biological education: A call to action. *BioScience* 52: 432. doi:10.1641/0006-3568(2002)052[0432:wtekib]2.0.co;2

Page Q2-24, after Smith et al. 2013

Smith, D. L., S.P. Miner, C. H. Theiling, R. Behm, and J.M. Nestler. 2017. Levee Setbacks: An Innovative, Cost-Effective, and Sustainable Solution for Improved Flood Risk Management. Environmental Laboratory, U.S. Army Corps of Engineers, Engineer Research and Development Centers. ERDC/EL SR-17-3. https://apps.dtic.mil/sti/pdfs/AD1036398.pdf

Appendix C
Attachment C-3.5
Proposed Appendix Q3. Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento-San Joaquin Delta

DRAFT

APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Delta Plan Amendments

May 2020

For assistance interpreting the content of this document, please contact Delta Stewardship Council staff.

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Phone: 916-445-5511

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Contents

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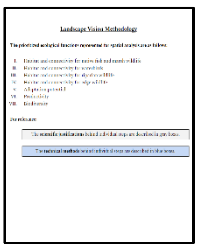
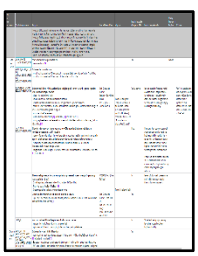
Introduction

This technical report describes the steps taken to rapidly develop a list of complementary opportunities for landscape-scale restoration in the Sacramento-San Joaquin Delta. It was designed to support Delta Stewardship Council staff who are actively developing an Ecosystem Amendment to the Delta Plan and is based upon the guide to science-based ecological restoration in the Delta previously developed by SFEI (A Delta Renewed, SFEI-ASC 2016). Taken together, the opportunities described and mapped in these materials represent a step towards the development of a Delta-wide landscape vision for supporting a holistic suite of desired ecological functions based on the strategies, guidelines, and recommendations put forth in the Delta Renewed report. Please note that work is still evolving; many of the opportunity types described below would benefit from further development and analysis.

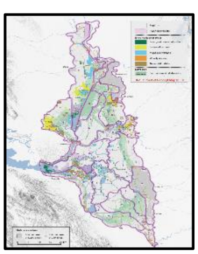
The landscape opportunities are described across several documents:



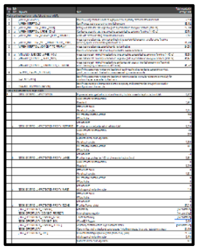
Methodology – a detailed description of the processes, analyses, and criteria used to identify, map, and quantify the opportunities for landscape-scale restoration. The methodology includes the reasoning behind each class or “type” of opportunity and the methods used to actually locate these opportunities on the landscape. The methodology introduces “codes” for the different types of opportunities that are then utilized in the other materials.



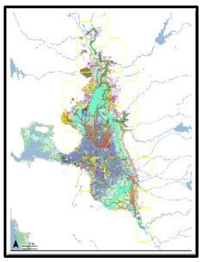
Opportunities Table – a description of opportunities for landscape-scale restoration in the Delta, organized by region. Spatially explicit opportunities are referenced with numbers that correspond to those used in the “Opportunities Map.” By referencing the methodology document, the opportunity type codes used in the table can be used to look up the scientific justifications and technical methods that supported the inclusion and mapping of the specific opportunities in the table.



Opportunities Map – a map of the specific restoration opportunities described and numbered in the “Opportunities Table.” Maps of individual layers that spatially represent each step in the methodology are also available as a separate package of layers accessible in GIS software.



Opportunities Summary – a numerical summary of conservation and restoration opportunities (as described and coded in the Methodology document). The summary quantifies, by type, the approximate total acreage of the opportunities described conceptually in the Methodology document.



GIS Map Package – a set of spatial data layers representing steps of the methodology. Map package contains organization of layers that is parallel to the ordering of steps and codes within the methodology. As described below in page 3, not all steps have spatially explicit data.

Methodology

The methods for identifying opportunities described below should be thought of as a checklist for conservation planning in the Delta. For this initial rapid analysis, some opportunity types were analyzed in more depth than others. A limited number of analyses associated with certain steps were not performed due to lack of data or time constraints. Overall, analyses were prioritized based on conservation interest (e.g., recovery of native fish populations is of high regional concern), quality of information (e.g., specific tidal marsh quantifications were based on availability in the scientific literature and review from the Delta Landscapes Project reports (Whipple et al. 2012, SFEI-ASC 2014, and SFEI-ASC 2016), and feasibility of analysis (e.g., adaptation potential is a more challenging function to plan for than support for riparian wildlife). Taken together, this information is analogous to a list of ingredients, rather than a recipe. The user must determine priorities for conservation and choose actions or sites accordingly.

The focus of this effort has been to describe kinds of opportunities spatially. To do so, these materials rely heavily on information that has been previously assembled in reports for the "Delta Landscapes Project": the *Sacramento-San Joaquin Delta Historical Ecology Investigation* (Whipple et al. 2012), *A Delta Transformed* (SFEI-ASC 2014), and *A Delta Renewed* (SFEI-ASC 2016). A familiarity with these documents will aid those reviewing the materials contained in this appendix. For example, when identifying opportunities for the conservation and restoration of habitat types, we do not define these habitat types, describe the processes required to sustain them over time, or describe how they differ across different parts of the Delta. Nor do we describe or define the ecological functions that organize the methods. All of this information is provided in the aforementioned reports.

We used the ecosystem functions analyzed in the Delta Landscapes Project reports to organize our methods into seven sections. Since habitat and connectivity for fish and marsh wildlife were the focus of our initial work on this effort, and since there is a high degree of overlap in the kinds of actions that might be taken to support the two functions, the methods used to identify opportunities to support these two functions are lumped. Future versions of this methodology could separate these two functions by:

- Habitat and connectivity for native fish and marsh wildlife
- Habitat and connectivity for waterbirds
- Habitat and connectivity for riparian wildlife
- Habitat and connectivity for edge wildlife
- Adaptation potential
- Productivity
- Biodiversity

For each step in the methods, we include a bracketed “code” in capital letters (e.g., [MARSH_REMNANTS]) that is used to identify opportunity types in the Opportunities Table and associated GIS files. We also include the **scientific rationale** behind each opportunity type and the **technical methods** used to identify opportunities on the map:

Under the technical methods description, we note whether the methods for identifying the opportunity areas were:

A. **[Identified automatically and quantified]** – identified using an automated, thorough, and repeatable GIS methodology. Opportunities that were identified automatically and quantified generally have detailed associated GIS outputs showing the locations of opportunities. These outputs were used to develop the “Opportunities Summary” spreadsheet. There is no extra label displayed in GIS map package layer.

B. **[Identified manually]** – opportunities were evaluated thoroughly, but done so using a manual approach that may not be perfectly repeatable. No associated spatially explicit GIS outputs. Labeled as {IM} in GIS map package layer. These layers may either contain no data or reference data that could be used for more comprehensive future analysis.

C. **[Identified in part]** – opportunities were evaluated in some areas, but not thoroughly, and may still be appropriate in areas where not noted. Generally, there are no associated spatially explicit GIS outputs, though in some cases opportunities that have been explicitly mapped, but not comprehensively added to the opportunities table and map, are characterized as “identified in part.” Labeled as {IP} in GIS map package layer. These layers may either contain no data or reference data that could be used for more comprehensive future analysis.

D. **[Not identified]** – due to time constraints or data limitations, no effort was made to identify opportunity areas for these steps; they should still be evaluated at a later date. Labeled as {NI} in GIS map package layer. These layers may either contain no data or contain reference data that could be used to begin future analysis.

Note that many of the assumptions and uncertainties associated with the materials produced for the Delta Landscapes Project have been carried forward into the identification of opportunities in this effort. A notable example of this relates to modeling sea level rise (SLR) in the Delta. As described in more detail in the relevant sections below, the approach employed to map areas potentially subject to tidal inundation with SLR was rudimentary; we simply added a fixed height of 6 feet to the current mean higher high water (MHHW) elevation (as measured at one location in Cache Slough) and identified anything below this new elevation as potentially at the future intertidal elevation range. These methods do not account for spatial variability in either existing tidal elevations or future increases in water surface elevations, which are largely unknown (Council 2018). Opportunity areas could be refined by addressing these uncertainties through improved modeling. In general, we attempt to highlight any major uncertainties associated with the identification of opportunity types in their individual methodology sections.

Habitat and Connectivity for Native Fish and Marsh Wildlife

1. Identify existing marshes (>1 ha) in need of legal protection, especially remnant historical marshes [MARSH_REMNANTS].

Scientific Rationale

Many of the Delta’s small marsh fragments have existed continuously since the historical period and are important potential reservoirs of native biodiversity. They could potentially serve as sources of propagules for new restoration projects (e.g., Chazdon 2003, Cramer et al. 2008), as "stepping stones" for wildlife dispersal (e.g., Saura et al. 2013), and as windbreaks that help limit fetch and wind-wave driven erosion of other areas in the event of levee failures and large-scale island inundation (e.g., Tonelli et al. 2010).

Technical Methods

Marsh remnants were identified in the GIS by selecting areas classified as freshwater emergent wetland in both the historical habitat types dataset and modern habitat types dataset (SFEI-ASC 2014). “Protected” areas were identified by merging three datasets: (1) the California Protected Areas Database (CPAD 2017), (2) the California Conservation Easement Database (CCED 2016), and (3) a layer containing the footprints of the islands/tracts owned by the Metropolitan Water District of Southern California (MWD), Bouldin Island, Webb Tract, Bacon Island, and Holland Tract. Areas of remnant marsh intersecting any of these datasets were considered protected; those that did not were considered unprotected. Note that we only evaluated that status of marsh areas that were part of marsh patches larger than 1 hectare (ha), as identified by SFEI-ASC (2014). Also note that the analysis overestimates the extent of true remnant marshes, since areas that underwent habitat conversion and subsequent restoration between the historical and modern mapping periods (e.g., Liberty Island) are indistinguishable from true remnants using these methods. **[Identified automatically and quantified]**

2. Identify areas that are currently at intertidal elevation [MARSH_INTERTIDAL].

Scientific Rationale

Large swaths of land in the Delta currently are situated at intertidal elevations but are separated from the tides by levees and other human infrastructure. These areas have the greatest potential to support tidal marshes with minimal management intervention now and into the future because, if connected to tidal action, they would be inundated at a depth and frequency that is appropriate for the establishment and persistence of emergent marsh vegetation. In general, these areas should be prioritized for restoration now, before their elevation becomes less favorable due to subsidence and SLR. In San Francisco Bay, the best available scientific guidance suggests restoring tidal marshes before 2030, since rates of SLR are expected to increase rapidly midcentury and time is needed for marshes to build elevation capital before this occurs (Goals Project 2015).

Technical Methods

Our methods for identifying areas at intertidal elevation were highly simplified. In absence of a comprehensive spatial dataset indicating the elevations of tidal datums across the Delta, we simply selected areas with elevations between a single mean lower low water (MLLW) elevation value (0.64 meter (m) NAVD88) and a single MHHW elevation value (1.95 m NAVD88). Once areas within this elevation range were extracted, we generalized the resulting raster data before converting it to polygonal vector data following methods described in ESRI's ArcGIS 10.5 generalization toolset documentation (Esri 2016). To highlight opportunity areas, we removed any areas classified as marsh or urban development in the modern habitat types dataset (SFEI-ASC 2014). Our source for elevation data was a 2 m Digital Elevation Model (DEM) of the Delta derived from DWR LiDAR data flown in 2007 (Reclamation 2010). The tidal datum elevations were measured at Cache Slough by cbec eco engineering (2010). These methods therefore make the major simplifying assumption that tidal range in the Delta is constant across space and time. We know this assumption is false, and therefore only use this layer to show the approximate location and extent of areas at intertidal elevation now and into the future. The layer should be refined for use in any detailed planning process. A simple visual inspection suggests general agreement with the areas within tidal demarcated by Siegel et al. (2010) using more sophisticated methods that account for spatial variability in the elevation of tidal datums. **[Identified automatically and quantified]**

Specific priorities include:

a Contiguous areas that are large enough to support desired ecological functions [MARSH_INTERTIDAL_LARGE].

Scientific Rationale

All else being equal, we expect larger marshes to support a wider range of desired ecological functions than smaller marshes (see SFEI-ASC 2016). For this analysis we focus on identifying areas that are large enough to potentially support maximum densities of Black rails (approximately 100 ha; N. Nur, personal communication) and areas that are large enough to potentially support a dendritic channel network (approximately 500 ha; SFEI-ASC 2016). These patch-size thresholds are relatively large, and marshes of these size would be expected to be large enough to support a variety of other ecosystem functions.

Technical Methods

Identified by creating patches from the areas at intertidal elevation (following methods developed for A Delta Transformed, SFEI-ASC 2014), then selecting patches larger than either 100 ha or 500 ha. **[Identified automatically and quantified]**

b Areas adjacent to existing marshes to increase patch size and connectivity.

Scientific Rationale

In some places, there are opportunities to restore large marsh patches (see above) by expanding on an existing smaller patch or by connecting multiple existing small patches, rather than restoring an entire new large patch outright.

Technical Methods

Due to time constraints, a detailed connectivity analysis of existing marshes has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

c Areas with remnant blind channel networks (it should be easier to recover complete marsh-channel systems where these channels have not been eliminated) [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL].

Scientific Rationale

Dendritic tidal channel networks that terminate within wetlands contribute to the exchange of energy, materials, and organisms between wetlands and aquatic areas, food-web production, and habitat heterogeneity, among other functions expected to benefit native fish (see SFEI-ASC 2016). Though the vast majority of the Delta's former blind channel networks have been eliminated since the historical period, remnant historical blind channels do still exist in some locations. Though these channels have been highly simplified over time (most have been truncated, straightened, and leveed), areas where they still exist at intertidal elevations offer relatively good opportunities to restore elements of a complete marsh-channel system (e.g., multi-order channels embedded within and hydraulically connected to areas of marsh).

Technical Methods

Identified by selecting “intertidal elevation patches” that intersect (or are within 100 m) of remnant historical blind channels. Remnant blind channels were identified by selecting any reach of modern blind channel (mapped in SFEI-ASC 2014) at least 1.35 kilometer (km) long that fell within 10 m of a historical blind channel (also mapped in SFEI-ASC 2014). **[Identified automatically and quantified]**

d Areas adjacent to tributaries with high inorganic sediment loads.

Scientific Rationale

Inorganic sediment delivery can supplement vertical marsh accretion from the accumulation of organic matter (Drexler 2011) and marshes with high sediment supplies might therefore have enhanced resilience to SLR over time.

Technical Methods

Due to time constraints, a detailed assessment of tributary sediment loads has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

e Areas that are adjacent to nonurbanized uplands to provide tidal-terrestrial transition zone functions (including space for marsh migration space with SLR), especially upland areas with existing terrestrial habitats (see Section IV, 1 below) [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE].

Scientific Rationale

It is important to identify areas where potential marshes have undeveloped uplands that can contribute to the formation of a tidal-terrestrial transition zone because this zone supports important environmental gradients, contributes to high levels of biodiversity, supports a wide range of ecological functions (e.g., high water refuge), and facilitates marsh migration over time with SLR (SFEI-ASC 2016).

Technical Methods

Identified by selecting “intertidal elevation patches” that intersect areas identified as nonurbanized migration space. For the purposes of this analysis, migration space was defined as any area between the elevations of 1.95 and 3.78 m NAVD88, which corresponds to the area within 1.8 m (6 feet (ft)) above present-day MHHW (as measured by cbec eco engineers [2010] at Cache Slough and mapped by SFEI-ASC [2016]). Nonurban areas were those that were not classified as urban/barren in the modern habitat types layer (SFEI-ASC 2014).

This analysis should be updated with a more sophisticated model of current and future tidal datums across the Delta. **[Identified automatically and quantified]**

f Areas that are adjacent to potential woody riparian habitats [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN].

Scientific Rationale

Historically, along the vast majority of their length, the Delta's elevated woody riparian corridors graded down to marshes (SFEI-ASC 2016). Marshes also graded into willow thickets in lower-elevation floodplains (Whipple et al. 2012, see Section II, 3). The existence of an ecotone between woody riparian habitats and marshes provides marsh wildlife with cover, high-water refuge, and alternate food sources (SFEI-ASC 2016). Adjacency between marshes and riparian habitats also benefits species that forage in marshes but roost, nest, or otherwise seek cover in riparian areas (such as colonial nesting birds). Marsh food webs can be supported by an influx of inputs from upstream terrestrial areas, and upstream riparian areas can export sediment and nutrients to support tidal marsh habitat. Landscape-scale restoration should seek to recover some of these lost functions by restoring woody riparian habitats adjacent to tidal and nontidal marshes (SFEI-ASC 2016; also see Section III, 2c, for reference).

Technical Methods

Identified by selecting "intertidal elevation patches" that intersect regions that historically supported woody riparian habitats and could potentially do so again; specifically, the historical footprint of valley foothill riparian, willow riparian scrub/shrub, and willow thicket habitat types (Whipple et al. 2012). See Section III, 1a and Section III, 3 for more information on identifying areas that could potentially support woody riparian habitat types. **[Identified automatically and quantified]**

3. Identify subsided areas that should be prioritized for reverse subsidence. [MINIMALLY_SUBSIDED].

Scientific Rationale

Much of the area that supported tidal freshwater emergent wetland has historically subsided due to the oxidation and compaction of peat soils that occurred as a result of agricultural production (Drexler 2011). "Reverse subsidence" efforts aim to recover lost elevation in these areas through managed wetlands that help to build organic material and trap sediment on site (Miller et al. 2008). These efforts are still in early stages in the Delta, however, reverse subsidence offers the potential to restore lost habitat value in these subsided areas, as well as potentially reducing flood risk over the long term, if these sites are able to regain intertidal elevations. The process of rebuilding peat soils is slow, and therefore the likelihood of achieving intertidal elevations through these methods is likely greatest in minimally subsided areas.

Technical Methods

Minimally subsided areas are lands mapped in A Delta Renewed that would require less than 50 years to reach intertidal elevation assuming constant elevation gains through tule farming of 5 cm per year (without SLR). Once these areas were isolated, we generated patches from the resulting layer following the methods for generating marsh patches described in SFEI-ASC (2016). This analysis would benefit from a more sophisticated model of the time it would take impounded marshes to reach intertidal elevations, taking into account key factors such as inorganic sediment supplies, SLR, and peat compaction (e.g., Deverel et al. 2014). **[Identified automatically and quantified]**

Specific priorities include:

a Areas that are both minimally subsided and large enough to support desired ecological functions (e.g., larger than approximately 100 ha for maximum densities of Black rail or 500 ha to support a dendritic channel network) [MINIMALLY_SUBSIDED_LARGE].

Scientific Rationale

See Section I, 2a above.

Technical Methods

Large areas were identified by selecting minimally subsided patches larger than either 100 ha or 500 ha. **[Identified automatically and quantified]**

b Areas that are minimally subsided and are adjacent to potential woody riparian habitats on natural levees [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN].

Scientific Rationale

See Section I, 2f above.

Technical Methods

Identified manually by locating minimally subsided areas that intersect natural levee features (historical woody riparian habitat type polygons). Could be automated, quantified, and refined in future phases. **[Identified manually]**

c Areas that are contiguous with areas at intertidal elevation and if restored would improve site hydrology and the potential for coherent dendritic tidal channel network development [SUBSIDED_HYDROLOGIC_BENEFITS].

Scientific Rationale

On leveed tracts that are at intertidal elevation at their higher end but are subtidal at their lower end, breaches would result in permanently flooded habitats between the existing channel network and any new marshes that form in the intertidal area. This habitat configuration would prevent the formation of dendritic channel branches directly off of the original channel network. Carrying out reverse subsidence in the subtidal area (e.g., as is planned as part of the Dutch Slough restoration) could allow for the development of a coherent dendritic channel network.

Technical Methods

Identified manually by locating tracts that have significant areas at intertidal elevation at their higher end but are subtidal at their lower end. Could be automated, quantified, and refined in future phases. **[Identified manually]**

d Areas that would meaningfully improve marsh patch connectivity at the landscape scale (see Section I, 4, and 5).

4. Identify the approximate number and locations of large tidal marshes with dendritic channel networks needed to support the survival, growth, and movement of native fish, as represented by juvenile salmonids [SALMON_REARING_NETWORK].

Scientific Rationale

This exercise is based on Delta Renewed guidelines concerning marsh patch size and nearest neighbor distances. The guiding principle is that restoration efforts should create a network of high-quality rearing habitats (particularly marshes with dendritic channels) that are distributed at regular intervals along key salmon migratory corridors. More specifically, if outmigrating juvenile salmon travel during the night and hold/forage in low-velocity refugia habitats during the day, we hypothesize that fish should benefit from gaps between marshes with dendritic tidal channels that are less than the distances they typically travel over a 24-hour period.

Technical Methods

Michel et al. (2013) observed Chinook salmon smolt mean successful migration movement rates (MSMMR) ranging from 14.3-23.5 km/day for different release groups. A mean of all release groups (weighted by the number of fish in each group) yields an average MSMMR of 19.3 km/day. Based on this research, we used location-allocation GIS tools to optimally locate rearing sites along migratory routes so that each site is within 19.3 km of another (the tool determines the minimum number of sites needed to provide complete coverage).

At the points identified by the location-allocation analysis as important, we generated 500 ha circles, the approximate area of marsh needed to support a full channel network (Whipple et al. 2012, SFEI-ASC 2016). The resulting spatial dataset serves as a rough visual guide to the number, size, and location of large marshes needed across the landscape to provide habitat and connectivity for native fish. It can then be modified and refined based on other criteria. **[Automated]**

5. *Identify the approximate number and locations of marshes needed to provide habitat and connectivity for marsh wildlife, as represented by Black rails [RAIL_NETWORK].*

Scientific Rationale

Marsh patches of at least approximately 1 km2 are needed to support maximum densities of Black rails (N. Nur, personal communication). In order to maintain connectivity and metapopulation viability, marsh patch nearest-neighbor distances should not exceed normal Black rail dispersal distance (5.58 km; Hall 2015). Since Black rail presence is positively correlated with tidal influence (Tsao et al. 2015), these patches would ideally be hydraulically connected, though benefits would also be expected through the creation of impounded marshes in subsided areas. It is possible that productivity from these nontidal wetlands could subsidize aquatic food webs through water management and other indirect pathways.

Technical Methods

To visualize what a connected landscape is with marsh patches that follow the above size and distance guidelines, we generated an idealized network of circular marshes, each 1 km^2 in size and located 5.58 km from at least three other patches (a hexagonal grid). The resulting spatial dataset serves as a rough guide for determining where additional marsh restoration is needed to provide habitat and connectivity for marsh wildlife at the landscape scale. **[Automated]**

6. *Identify opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts. [CHANNEL_RECONFIGURATION].*

Scientific Rationale

Channel cuts have very likely contributed to decreased aquatic habitat heterogeneity at the landscape scale (Lund et al. 2007, Enright 2008, Whipple et al. 2012, Safran et al. 2016). Changes in network topology that increase the connectivity of a system, such as channel cuts, can also make it easier for disturbances to be transmitted through the network, resulting in more tightly correlated extinction risks for organisms in different parts of the system (Jones et al. 2000 as cited in Grant et al. 2007). It is conceivable, for example, that increased hydrologic connectivity in the Delta has facilitated the spread of invasive aquatic organisms like the overbite clam and Brazilian waterweed. It may be possible to reduce the over-connectedness of aquatic habitats and to regain some level of habitat heterogeneity through the careful use of physical barriers. These could be positioned at the sites of channel cuts, effectively limiting the influence of artificial hydrologic connections that were created during the reclamation era. Finally, the reconfiguration channel networks through physical barriers also have the potential to reduce entrainment of organisms in water export facilities (e.g., Ateljevich and Nam 2017).

Technical Methods

Identified manually by reviewing historical channel cuts highlighted in Delta Transformed (SFEI-ASC 2014). Future efforts should model actual hydrodynamic changes expected from these actions. **[Identified manually]**

7. ***Identify opportunities to create water temperature refugia through vegetative shading and by increasing the connectivity of channel networks to groundwater sources.***

Scientific Rationale

Cooler water refugia are important for alleviating stressors for marsh wildlife, particularly native fish. Increasing connectivity of channel networks to groundwater sources can sustain channel and wetland complexes throughout different times of the year. As these opportunity types pertain much to riparian wildlife, these types of opportunities are discussed in more detail in Section III.

Technical Methods

Opportunities to increase shade from woody riparian vegetation are captured in section, Habitat and Connectivity for Riparian Wildlife). Opportunities for riparian shading specifically for fish have not yet been comprehensively evaluated or incorporated into the vision. The same is true of opportunities to increase cold-water refuge through groundwater connections. **[Identified in part]**

8. ***Identify tidal-fluvial transition zones with strong inverse relationships between inflow and juvenile salmon survival, where habitat restoration might be prioritized [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT].***

Scientific Rationale

In the Delta, the location where flows in channels shift from tidally dominated (bidirectional) to fluvial-dominated (unidirectional) moves in response to the magnitude of freshwater inflow. These zones have a variety of unique physical and biological characteristics that make them important to wildlife and native fish. During high-flow periods the influence of the tides is “pushed” to the seaward end of the zone. This reduction in the spatial extent of tidal action partially accounts for the increase in survival of juvenile salmon during high-flow periods. Salmon would be expected to benefit from the restoration of channel edge and off-channel habitats that improve survival and growth within these zones (Cavallo et al. 2013, Perry et al. 2018).

Technical Methods

North Delta tidal-fluvial transition zones were mapped from Perry et al. (2018). San Joaquin River fluvial zone was mapped from Cavallo et al. (2013). Restoration opportunities in these zones were then manually identified and noted in the landscape vision. However, due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Identified in part]**

9. Identify remnant topographic low points at the sites of former lakes and flood basins, which could support long-duration inundation [TOPOGRAPHIC_LOWS_LONG_TERM_INUNDATION].

Scientific Rationale

In the Delta, historically topographic low points supported long-duration inundation, to provide spatial and temporal heterogeneity in habitat. That is, these area provided open water habitat in certain areas and times when other places were dry. Particularly, in the North Delta, flood basins, running parallel to the river, accommodated large-magnitude floods, which occurred regularly, with inundation often persisting for several months. They consisted of broad zones of nontidal marsh that had very few channels and transitioned to tidal wetland towards the central Delta. Dense stands of tules over 3m tall grew in these basins. Large lakes occupied the lowest points in these flood basins (SFEI-ASC 2016).

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

Habitat and Connectivity for Waterbirds

1. Identify existing wetland, aquatic, and connected terrestrial habitat types in need of legal protection.

Scientific Rationale

Support for waterbirds is provided by a diversity of wetland types. While opportunities for waterbirds were not specifically analyzed for this effort, many of the recommendations for other functions would also benefit waterbirds. Specifically, the creation of large marsh areas, woody riparian habitats adjacent to marshes, and terrestrial areas that support seasonal wetlands all would be expected to support waterbirds. Agriculture also can play a key role in supporting waterbirds in the Delta. Analyses that consider how the landscape configuration of managed and unmanaged wetlands and wildlife-friendly agriculture support waterbirds should be addressed in future work, and have been to some degree already (e.g., Reynolds et al. 2017). Overall, protecting areas of persistent habitat type, particular habitat value and restoring large unprotected areas of the habitat types described above are important in providing ecological support for habitat and connectivity for waterbirds.

Technical Methods

To perform this basic analysis, methods describing protecting each of the above-described habitat types has, for the most part, been addressed in other sections. For marshes, see Section I. For woody riparian forest, see Section III. For vernal pools and seasonal wetlands, see Section IV. Open water (e.g., lakes) and floodplain habitat types may be addressed by future analyses. In summary, due to time constraints, opportunities for this type of action have either been evaluated for other functions in other sections, or have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

a. Identify existing habitats of significant value to specific populations.

i. Sandhill crane roosting sites.

Scientific Rationale

Sandhill cranes have high site fidelity for roosting sites. Protecting these sites are of particular importance, especially given that they are a species of conservation concern.

Technical Methods

Due to time constraints and data availability, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

ii. Remnant riparian habitat likely to support old-growth woody riparian forests.

Scientific Rationale

Particular trees can have an outsized ecological impact, with single trees containing dense concentrations of colonial nesting birds. In the long run, protecting and maintaining woody riparian forest habitats in general is an important consideration, as these habitats will sustain processes to provide future habitat for such focal bird species.

Technical Methods

Due to time constraints and the fine-scale resolution of data required for this analysis, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision, but the conservation of remnant riparian habitats is captured in Section III, 1a. **[Not identified]**

b Identify other existing important habitats to support a diversity of waterbirds.

Scientific Rationale

Protecting a diversity of wetland and aquatic habitat types can promote a diversity of waterbirds. Wetlands with vegetation of different heights (such as short-stature vegetation like wet meadows and complex emergent wetlands typical of the historical south Delta), as well as wetlands with varying water depths and inundation timing, support different niches of birds and at different times of the year. It is important to include marshes, riparian forests, seasonal wetlands, floodplains, and lakes to address aspects of habitat and food-web support for all waterbirds. Floodplains in the Yolo Bypass and along the Cosumnes and San Joaquin Rivers would support shorebirds and dabbling ducks. Riparian and riverine habitats on the Sacramento, San Joaquin, and Cosumnes Rivers, as well as on smaller tributaries, would support Wood ducks, mergansers, herons, and egrets. Lakes are important for supporting large numbers of waterfowl, and vernal pools and seasonal wetlands are important for cranes and shorebirds. Wildlife-friendly agriculture throughout the Delta can benefit various waterbirds, depending on crop types and flooding patterns. The areas along the periphery of the Delta are more likely to be sustainable for waterbird support in the long term as sea level rises. Terrestrial habitats also provide support for some waterbirds during different times of the year—shorebirds use vernal pools, while various waterbirds such as cranes utilize seasonal wetlands (SFEI-ASC 2016).

Technical Methods

See Section II, 1 for more details. **[Not identified]**

2. Identify opportunities for restoring wetland, aquatic and connected terrestrial habitat types.

a Diversity of wetland and aquatic habitats.

Scientific Rationale

Restore and maintain a diversity of wetland and aquatic habitat types including marshes, riparian forests, seasonal wetlands, lakes, and floodplains. Include wetlands with short-stature vegetation, including wet meadows and complex emergent wetlands typical of the south Delta, historically.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

i. Restore wetlands of large size to support adequate food production for large flocks of waterbirds.

Scientific Rationale

Large wetlands should be created and managed to support large flocks of overwintering waterfowl. Prioritization of large tidal marshes based on other functional thresholds are described under Section I. For instance, 500 ha marshes provide significant habitat heterogeneity by allowing the development of a full dendritic channel network. Marshes of this size should also contribute substantial primary productivity for waterbird uptake. However, full analysis of these functional benefits of primary productivity are still in progress. As such, particular recommended acreage thresholds are not available at this time. Restoring various wetland habitat types can provide different types of primary productivity. Overall, large-scale wetland habitat type restoration is recommended to support food webs.

See Section VI for more on productivity.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

b Restore and maintain connected terrestrial habitats around the periphery of the Delta, including vernal pools for shorebirds and seasonal wetlands for other waterbirds.

Scientific Rationale

Terrestrial habitats are important for waterbirds for two primary reasons. First, areas along the periphery of the Delta are more likely to be sustainable for waterbird support in the long term as sea level rises and shifts habitat on elevational and various other environmental gradients. Secondly, terrestrial habitats provide support for some waterbirds during different times of the year than other habitat types in other locations—allowing shorebirds to use vernal pools and various waterbirds such as cranes to utilize seasonal wetlands (SFEI-ASC 2016).

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

c Restore and maintain riparian forest habitat near marshes to support colonial roosting and cavity nesting birds.

Scientific Rationale

See Section IV, 1b-ii for explanation as well as supporting information in Section I, 2f and Section III, 2c.

Technical Methods

Due to time constraints and the fine-scale resolution of data required for this analysis, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision, but areas that could potentially support riparian habitats adjacent to marshes are identified in Section I, 2f and Section III, 2c. **[Not identified]**

3. Identify opportunities to integrate waterbird habitat into human land uses.

a Wildlife-friendly agriculture.

i. Manage a network of foraging habitats in the form of short-stature managed wetlands or seasonally flooded agricultural fields (particularly for cranes).

Scientific Rationale

Restoring a network of seasonally flooded habitats could take many forms, including primarily rain-fed seasonal wetland complexes, nontidal freshwater emergent wetlands, managed wetlands, and/or seasonally flooded agricultural fields.

Restoring wetland habitat types that can be sustained by natural processes (such as floodplain habitat) and are not managed or managed with low intensity is desirable. Where process-based restoration is not feasible, a more managed approach is possible through cultivating managed wetlands and managed flooding in farm fields.

Given that most of the modern Delta is under agricultural with heavily variable and managed water operations, perhaps the most potential for habitat modification lies here.

Delta Transformed (SFEI-ASC 2014) also suggested general metrics around monitoring and planning for waterbirds by measuring and evaluating ponded area in summer by depth/duration and wetted area by type in winter. The variance in depth and timing of water in space across the Delta is important to plan strategically to support sandhill cranes as well as a suite of other waterbirds.

While more analysis and research is potentially needed for this topic, some literature has established some management guidance specifically for sandhill cranes. Given their relatively long dispersal distance and large biomass, cranes can be used as an umbrella species for many other waterbirds. This research suggests new roosting habitat should be established as close as possible to the original site, or within 5 km of foraging habitats. This 5 km radius comes from analysis for sandhill cranes (Ivey et al. 2015). However, some shorebirds may prefer shallower depths on agricultural fields, and waterfowl will prefer greater depths.

The Nature Conservancy has already done significant analysis around this topic for a variety of shorebirds, in further detail, at both finer resolution and greater scale (for instance, see Reynolds et al. 2017) to target supplying water on fields when and where it is most needed to support this ecological function.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. See Reynolds et al. 2017 and other similar efforts by The Nature Conservancy for more detailed planning analyses in the Central Valley, including the Delta. **[Not identified]**

ii. Offset lost agricultural waterbird habitat (from tidal marsh restoration) in other areas.

Scientific Rationale

Flooded agricultural fields currently provide critical support to migratory waterbirds. Planned tidal marsh restoration in agricultural areas that currently support waterbirds may displace species that prefer more open, deeper water, short-stature vegetation and agricultural grain fields to mudflats and taller vegetation. Offset foraging or roosting habitat then should be designed to accommodate a diversity of species, with strategic managed flooding of variable timing, depths, and locations.

See Section III, 3a-i for more details on characteristics of wildlife-friendly agricultural habitat for sandhill cranes.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. See Reynolds et al.

2017 and other similar efforts by The Nature Conservancy for more detailed planning analyses in the Central Valley, including the Delta. **[Not identified]**

b Integrate habitat improvements in urban areas.

Scientific Rationale

Creating and improving the habitat quality of urban wetlands, ponds, and lakes—including improving water quality and quality of surrounding terrestrial habitat—could potentially benefit resident and migratory waterbirds and, by connecting people to wildlife, help to foster an understanding and appreciation for stewardship and conservation efforts.

Technical Methods

Due to time constraints, opportunities for this type of action have not yet been comprehensively evaluated or incorporated into the vision. **[Not identified]**

Habitat and Connectivity for Riparian Wildlife

1. Identify existing patches of woody riparian vegetation in need of legal protection [RIPARIAN_EXISTING_UNPROTECTED].

Scientific Rationale

Existing woody riparian habitats provide a wide range of functions to support riparian wildlife in the Delta (see SFEI-ASC 2016). Even small patches have the potential, for example, to serve as sources of propagules for new restoration projects (e.g., Chazdon 2003, Cramer et al. 2008) and as "stepping stones" to facilitate wildlife dispersal (e.g., Saura et al. 2013). However, many areas of existing woody riparian habitat in the Delta lack meaningful legal protection. Since the functional benefits and future resilience of woody riparian patches vary widely across the Delta (for instance, woody riparian vegetation directly connected to riverine flows at the upstream edges of the Delta probably has a higher functional value to wildlife and long-term resilience to change than woody riparian habitat on the landward side of an artificial levee in the central Delta), in the sections below we highlight the importance of protecting woody riparian habitats that are historical remnants, are hydrologically connected to streams, or have an appropriate natural landscape position (located within the fluvial or tidal-fluvial transition zone).

Technical Methods

Protection opportunities for existing woody riparian vegetation were identified by using a composite of modern woody riparian habitat types from the contemporary habitat type layer (SFEI-ASC 2014). Specifically, the modern woody riparian habitat types layer is formed from the valley foothill riparian, valley foothill alliance, willow thicket, willow riparian scrub/shrub, and willow scrub/shrub alliance habitat types (see SFEI-ASC 2014 for more information on the modern habitat type layer). Unprotected parcels were identified by intersecting the modern woody riparian habitat types with a protected areas dataset, developed by merging the California Protected Areas Database (CPAD 2017), the California Conservation Easements Database (CCED 2016), and a layer containing the footprints of the islands owned by MWD ,Bouldin Island, Webb Tract, Bacon Island, and Holland Tract). **[Identified in part]**

Specific priorities include:

a Existing woody-riparian patches that are historical remnants [RIPARIAN_EXISTING_UNPROTECTED_REMNANT].

Scientific Rationale

Historical remnants are potential pools of native biodiversity and are likely connected to the physical processes necessary to sustain the habitat over time (or could potentially be reconnected to these processes). Since they are very likely adjacent to other areas that could potentially support woody-riparian habitats, historical remnants are also likely to be critical components of any future riparian corridors.

Technical Methods

Woody riparian remnants were identified by using the intersect tool to find the overlap of the historical and modern woody riparian habitat types mapped by SFEI-ASC (2014). These areas of overlap were then intersected with the protected areas dataset (see above) to isolate unprotected remnants. Note that the analysis overestimates the extent of true remnant woody riparian vegetation, since areas that were cleared and have subsequently revegetated between the historical and modern mapping periods (e.g., trees growing on engineered levees) are indistinguishable from true remnants using these methods. Not all mapped opportunities have been highlighted in the opportunities table/map. **[Identified in part]**

b Existing woody riparian habitats that are hydrologically connected [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED].

Scientific Rationale

Hydrological connectivity is an important consideration for woody riparian habitat conservation because periodic deliveries of water and sediment are required to maintain the environmental conditions (e.g., moisture gradients and groundwater levels) and geomorphic surfaces (e.g., natural levees and point bars) that sustain woody riparian habitats and their associated functions over time (SFEI-ASC 2016). Note that the potential value of hydrologically disconnected woody riparian vegetation and opportunities for its conservation are discussed elsewhere (see Section III, 2g).

Technical Methods

For this analysis we selected woody riparian areas determined by SFEI-ASC (2014) to have some sort of hydrologic connection (areas classified as “valley foothill riparian,” “willow riparian scrub/shrub,” and “willow thicket,” but not areas classified as “valley foothill alliance” or “willow scrub/shrub alliance”). These hydrologically connected woody riparian areas were then intersected with the protected areas’ dataset (see above) to isolate areas of hydrologically connected but unprotected woody riparian vegetation. Not all mapped opportunities have been highlighted in the opportunities table/map. **[Identified in part]**

2. Identify remnant natural levees where woody riparian vegetation (both riparian forest and riparian scrub) could potentially be restored if reconnected to adjacent streams. [RIPARIAN_POTENITAL_ON_NATURAL_LEVEES].

Scientific Justification

Natural levees historically supported the majority of woody riparian vegetation along streams in the historical Delta, but have since largely been cleared, elevated, and armored over time with the construction of engineered levees (Whipple et al. 2012, SFEI-ASC 2014). Process-based restoration of these features would entail removing or regrading the engineered levees to allow for the reestablishment of woody riparian vegetation that is hydrologically connected to the adjacent stream and subject to associated natural processes (e.g., seasonal flooding, sediment scour and deposition, seed dispersal and seedling establishment). Natural levees are located within the Delta's fluvial zones, with relatively high freshwater flows, rates of sediment delivery, and proportions of well-drained mineral soils, which are all factors that would be expected to promote the establishment and survival of woody riparian vegetation (Griggs 2009). Restoration along natural levees should seek to restore vegetation across the complete gradient of fluvial influence, with larger natural levees supporting riparian forest upstream grading down to smaller natural levees supporting riparian scrub further downstream (Whipple et al. 2012, SFEI-ASC 2014, SFEI-ASC 2016).

Technical Methods

As an initial method for rapidly identifying remnant natural levees that could potentially support woody riparian vegetation in the Delta, we simply selected the historical footprint of valley foothill riparian and willow riparian scrub/shrub (Whipple et al. 2012). This methodology makes the simplifying assumption that areas that historically supported woody riparian vegetation could still do so today, at least with modifications to engineered levees that currently limit connections between streams and the adjacent land. Future phases of this work should refine this analysis, evaluating the actual present-day topographic, edaphic, and hydrologic conditions. As a first step towards refining the historical woody riparian vegetation footprint, we subtracted areas that have undergone urban development (as identified in the modern habitat type layer, SFEI-ASC 2016), based on the assumption that these developed areas are not good potential sites for woody riparian vegetation restoration. To isolate opportunities for restoration, we also subtracted areas of existing hydrologically connected, woody riparian habitats (those classified in the modern habitat type layer [SFEI-ASC 2014] as valley foothill riparian of willow riparian scrub-shrub). The methodology here potentially underestimates opportunity in areas that did not historically support woody riparian vegetation but could today, given changes in environmental conditions (e.g., along new channel courses such as Paradise Cut). These areas are the focus of Section III, 5. **[Identified automatically and quantified]**

Specific priorities include:

a Areas expected to enhance connectivity between existing wide patches of woody riparian habitat (prioritize restoration of gaps in existing riparian corridors) [RIPARIAN_EXISTING_GAPS].

Scientific Justification

In the fluvially dominated areas along streams, riparian corridors in the Delta were largely continuous swaths of woody vegetation, transitioning from tall valley foothill riparian forests upstream to willow riparian scrub downstream. In the contemporary corridor, these corridors have numerous and sizeable gaps and existing patches of riparian vegetation are often quite isolated (SFEI-ASC 2016). This is problematic, because connectivity between riparian habitats is important for sustaining ecological processes and functions. In terms of wildlife, gap sizes of varying distances can reduce probability or capacity of movement between riparian forest patches for such riparian wildlife as songbirds and mammals (see A Delta Renewed). These gaps can thus create barriers to movement and consequently, potentially reduce resilience and persistence of populations (e.g., Cecala et al. 2014). Connectivity of riparian habitats would also be expected to help facilitate pollination, dispersal, and gene flow within and between riparian plant populations.

Technical Methods

Gaps in existing patches of riparian vegetation along the Cosumnes, Mokelumne, and San Joaquin Rivers' systems were identified manually using spatial data developed for A Delta Transformed (SFEI-ASC 2014). Specifically, we reviewed the map of modern riparian width transects (pg. 67), which were generated wherever existing hydrologically connected, woody riparian vegetation is wider (laterally) than 100 m, and manually identified any longitudinal gaps in these wide habitats greater than 100 m. There was no maximum gap distance, but we only identified gaps in areas that historically supported woody riparian vegetation along natural levees (see above), which did impose an effective maximum gaps size. Future efforts should expand this analysis to other streams (especially the Sacramento River and its tributaries) and generate methods to identify gaps in an automated and repeatable fashion. **[Identified in part]**

b Areas that could potentially support woody riparian patches that are large and wide.

Scientific Rationale

Woody riparian corridors should be as wide as feasible, since the functions supported by woody riparian corridors generally increase with their width, and wide corridors have been disproportionately lost in the Delta over time (see SFEI-ASC 2016). Though relatively narrow corridors can provide some functions (e.g., corridors at least 5-25 m wide are needed to ensure leaf litter inputs to streams), many functions are only achieved at greater widths (e.g., optimal nesting habitat for Western yellow-billed cuckoo is at least 600 m wide). Wide corridors are also more likely than narrow corridors to support complex riparian habitats, with different vegetation zones influenced by lateral gradients in elevation, moisture, inundation frequency, and edaphic conditions (SFEI-ASC 2014).

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. It could be done in the future by intersecting the historical riparian width transects (mapped in SFEI-ASC 2014) with the layer of undeveloped areas that historically supported woody riparian habitats on natural levees (see above). This would allow one to measure the width of the remaining opportunity areas and to identify areas wider than a particular threshold. **[Not identified]**

c ***Areas that are adjacent to existing or potential marshes.***

Scientific Rationale

Historically, along the vast majority of their length, the Delta's elevated woody riparian corridors graded down to marshes (SFEI-ASC 2016). The existence of an ecotone between woody riparian habitats and marshes provided riparian wildlife with access to wetland habitats for foraging and adjacent marshes can also help dissipate flood waters that move through riparian habitats, reducing flood heights within the riparian corridor and associated mortality of terrestrial animals like riparian woodrat and riparian brush rabbits (SFEI-ASC 2016). Landscape-scale restoration should seek to recover some of these lost functions by restoring woody riparian habitats adjacent to tidal and nontidal marshes (SFEI-ASC 2016).

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. It could be done in the future by selecting potential areas for woody riparian habitats that are within a certain distance of areas deemed appropriate for marsh restoration (see Section I, 2f). **[Not identified]**

3. ***Identify areas near the mouths of Delta tributaries that could potentially support willow thickets.***

Scientific Rationale

In the historical Delta, large willow thickets were located at the mouths of multiple Delta tributaries where the water carried by these streams dissipated into the Delta's flood basins through distributary channel networks. The willow thickets that formed at these sites (known historically as "sinks") are notable, in part, because they were sustained by a different suite of physical processes than woody riparian habitats on natural levees and, as a result, had a different form and function (willow thickets were perennially wet and occupied lower-elevation floodplain positions relative to riparian forest habitat types). Since this unique habitat type has been effectively extirpated from the Delta, it's worth assessing areas near the mouths of Delta tributaries to determine if willow thickets could potentially be restored. Willow thickets, as treated here, are different from the willow-fern swamps of the central Delta, which are the subject of Section III, 4 below.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. As an initial method for identifying opportunity areas for restoring willow thickets, future analyses could map the areas that historically sustained these features (Whipple et al. 2012), minus the portions that have since undergone urban development (mapped in SFEI-ASC 2014). It is important to note that Whipple et al. (2012) only mapped large and well-defined expanses of willow: smaller patches of willow thickets were found elsewhere. A more refined analysis would evaluate the actual present-day topographic, edaphic, and hydrologic conditions to determine where willow thickets might be supported. **[Not identified]**

4. Identify locations in the central Delta that could support willow-fern swamps.

Scientific Rationale

Whipple et al. (2012) describe the historical presence of willow patches ("willow-fern swamps") embedded within the freshwater tidal marshes of the central Delta. Though willow-fern swamps were less connected than woody riparian habitats along natural levees, willow-fern swamps offered the only significant areas of woody vegetation in the central Delta, contributed to the heterogeneity of riparian habitats at the landscape scale, and likely supported riparian wildlife—particularly breeding riparian birds (Whipple et al. 2012, SFEI-ASC 2014).

Outright restoration of this plant community should be considered as part of tidal marsh restoration projects in appropriate parts of the central Delta (see below). Additionally, it may also be feasible to support willow groves in subsided portions of the central Delta, either as a component of impounded nontidal wetlands or in other landside areas where reconnection is not possible given water surface/land surface elevations. Sizeable willow groves are located on Sherman, Twitchell, Bradford, Webb, and Venice Islands/Tracts and indeed have been documented to support riparian wildlife (R. Melcer, personal communication). An important caveat is that the long-term sustainability of willow groves in subsided areas is threatened by continued SLR and the potential for levee failure. Such restoration efforts could be viable and provide benefits to riparian wildlife over shorter timescales, especially when coupled with subsidence reversal projects.

Willow-fern swamps are thought to have been most common historically within Sherman, Bradford, Webb, Venice, and Mandeville Islands; areas coincident with areas of cooler temperatures due to the maritime influence and tule fog (Whipple et al. 2012). The vegetation community is also thought to have occurred on Bethel, Franks, Holland, Quimby, Medford, Bacon, Orwood, Palm, Veale, and Hotchkiss Islands/Tracts. The full region—across which willow-fern swamps are thought to have occurred historically, and thus where it might make sense to prioritize their restoration today—is mapped in figure 4.50 in Whipple et al. (2012). An early map suggests there were approximately 7 patches of willow-fern swamp per 10,000 ha of land, each with an average size of approximately 16 ha

(SD = 12 ha, SFEI-ASC 2014). In absence of other information, projects might strive for restoring willow groves in this general configuration.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. As an initial method for identifying broad areas of opportunity for restoring willow-fern swamps, we simply have highlighted the region across which the vegetation community historically occurred (Whipple et al. 2012). Future phases of work could refine this analysis, evaluating the actual present-day topographic, edaphic, and hydrologic conditions to determine where willow-fern swamps might be supported. Efforts could also be made to visualize the historical size/distribution of willow patches across this area for reference during conservation planning efforts (see Section I, 5 for a similar example). **[Not identified]**

5. Identify areas that did not historically support woody riparian vegetation, but could now, due to environmental changes.

Scientific Rationale

The opportunity types identified above for supporting riparian wildlife emphasize recovering woody riparian habitats in areas where they were historically supported. This makes sense for identifying high-level opportunities for process-based restoration, but fails to account for areas where physical processes have been altered and "new" areas that could support woody riparian vegetation over the long term. Due to creation of new channels or changes in channel morphology, elevation, flows, or water control structures, there are areas that did not historically support extensive woody riparian habitats that could potentially support them now and into the future. Good examples of this include Paradise Cut in the south Delta and portions of the Yolo Bypass in the north Delta.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. A first cut at methodically identifying these areas could be accomplished by using the historical and contemporary channel layers to isolate new channel courses and then selecting those new courses that fall within the fluvial zone (And are thus potentially subject to the physical processes that support woody riparian vegetation over time). **[Not identified]**

6. Identify opportunities to increase support for riparian species in urban areas, through the restoration and buffering of urban creeks.

Scientific Rationale

Opportunities exist to improve riparian habitat along urban creeks and tributaries. Waterways in urban areas may be of particular importance in drought years for wildlife, as the waterways are often supplemented by artificial irrigation from urban landscaping and gardening operations (e.g., Solins et al. 2018). Further, creeks in urban areas have the potential to support regional corridors for connectivity (Urban et al. 2006) and can export nutrients and sediment downstream (Paul and Meyer 2001). These areas also provide convenient places for humans to connect with nature and can foster an understanding and appreciation for stewardship and conservation efforts (e.g., Standish et al. 2013).

In addition to restoration of areas within existing stream-area footprints, daylighting streams to improve hydrological and ecological connectivity is also an option, as is reconfiguring the sewershed network.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

7. Identify opportunities to increase support for riparian species in agricultural areas.

Scientific Rationale

There are a variety of well-established best management practices for supporting riparian wildlife in agricultural landscapes. The Riparian Habitat Joint Venture (2004) recommendations for managers include (1) use groundcover in orchards and vineyards to discourage foraging by Brown-headed cowbirds, (2) either avoid mowing through the nesting season or maintain the layer to 6 inches in height to discourage use by nesting birds, (3) use integrated pest management or organic production as an alternative to pesticide use, (4) eliminate, reduce, or closely manage grazing in spring and during the breeding season (April-July) to maximize the understory habitat value to wildlife and minimize foraging habitat for cowbirds, and (4) if grazing must occur in riparian zones, establish wide pastures and move cattle often to avoid the devastating impacts of year-round grazing. They also recommend planting hedgerows at field margins and managing nonnative plants and animals. These could be particularly useful to increase landscape connectivity in key areas where process-based woody riparian restoration is not feasible.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

Habitat and Connectivity for Edge Wildlife

Scientific Rationale

Terrestrial habitat types (including seasonal wetlands, vernal pool complexes, alkali wetlands, oak woodland/savannah, grassland, and stabilized interior dune vegetation) that were historically found along the periphery of the Delta are important to a wide range of terrestrial or “edge” wildlife species (defined in A Delta Renewed) and can provide crucial areas of connectivity and exchange in the tidal-terrestrial transition zone. These terrestrial habitats are considered together here because of their similar landscape position and because they support overlapping ecological functions. While these habitats were largely limited to the Delta periphery historically, today they often occur in deeply subsided areas of the Delta, behind levees, where they are less sustainable and do not provide the full suite of processes and functions expected.

Terrestrial habitat types occurring at appropriate elevations are most likely to persist over time, and the range of “appropriate” elevations is expected to shift with sea level rise. To most conservatively identify what terrestrial habitats may persist in tomorrow’s Delta, protection and restoration of potential terrestrial habitat cover should focus on areas above current MHHW, plus 6-feet (1.8 m) projected SLR. Areas above this elevation should be less vulnerable to SLR.

Terrestrial habitat protection in urban areas is assumed to be a low priority because of the degree of fragmentation and stressors in urban areas.

Thus, the footprint that develops to prioritize restoration of terrestrial habitat types is those lands above the MHHW plus 6-feet (1.8 m) elevation, minus lands currently urbanized.

Technical Methods

The terrestrial upland layer was developed by extracting areas from the DEM (Reclamation 2010) higher than 3.78 m NAVD88, which corresponds to the area at least 1.8 m (6 ft) above current MHHW, as measured by cbec eco engineers [2010] at Cache Slough and mapped by SFEI-ASC (2016). This land, predictably, falls mostly on the periphery of the Delta. For more information on identifying tidal-terrestrial transition zone areas, see Section I, 2e. Nonurbanized areas were isolated by subtracting any areas classified as urban/barren in the modern habitat types layer (SFEI-ASC 2014). **[Automated]**

1. ***Identify areas of existing terrestrial habitat types in need of legal protection. [EDGE_EXISITING_UNPROTECTED].***

Scientific Rationale

Though agriculture is the dominant land cover in the Delta, and much of the existing native habitat types are protected, opportunities remain to protect remnant, persistent or otherwise extant habitat types. Areas of high-quality habitat that are not yet protected should be the highest priority for acquisition or easement, as these likely harbor the highest biodiversity.

Technical Methods

Existing unprotected terrestrial habitat types were identified by the following process: taking the modern habitats layer (not including open water, agriculture or urban/barren lands) and subtracting current protected areas, and then intersected with the terrestrial upland zone. The protected areas were taken from a merged dataset of the CPAD 2017, the CCED 2015, and a layer containing the footprints of the islands owned by MWD, Bouldin Island, Webb Tract, Bacon Island, and Holland Tract. These lands collectively represent lands owned in fee or protected for open space purposes by many nonprofits and government agencies. Please note that this protected areas' layer utilizes an older (2015) version of the CCED database than other analyses identifying existing habitats in need of legal protection (e.g., Section I, 1 and Section III, 1); in future phases of work the analyses should be re-run with the latest 2016 version. **[Identified automatically and quantified]**

Specific priorities include:

a Protect as many remnant areas of high-quality habitat as possible. [EDGE_EXISITING_UNPROTECTED_PRIOITY_REMNANT].

Scientific Rationale

Habitats of historical persistence are of interest as they represent areas of unique genetic diversity and likely represent pools of native biodiversity that could colonize new areas and serve as high-quality habitats to link to broader landscape connectivity (Chazdon 2003). Restoration often may only "restore" a subset of the habitat features, processes and species historically present, so emphasizing these areas is of particular importance.

Technical Methods

Remnants are identified in the GIS by selecting areas with the same historical and modern habitat type classifications. The CPAD and CCED databases are then used to determine which remnants are in need of formal protection. As a technical note, grassland remnants in particular are difficult to classify accurately, as persistent native plant cover may be low given the invasion of European Mediterranean annual grasses. **[Identified automatically and quantified]**

b Protect largest, least-isolated existing habitat patches first. [EDGE_EXISITING_UNPROTECTED_PRIOITY_LARGE].

Scientific Rationale

Large patches are more likely than small patches to support high levels of species diversity and support the physical and biological processes needed to sustain desired ecosystem functions over time (Rosenzweig 1995, Peterson et al. 1998). Large patches are also likely the most resilient to future disturbances, including climate change, since they have more contiguous space available for the movement of populations and communities. Fifty hectares could be used as a threshold for identifying a minimum size for a "large" terrestrial patch, given its threshold support for biodiversity for terrestrial habitat (Helzer and Jelinski 1999).

Identifying and protecting less isolated patches can assist population resilience by improving metapopulation health, where patches close to others can harbor source populations for emigration, and immigration to new sites in part as a function of distance. Isolation also matters in terms of daily or seasonal movement, as terrestrial species have various thresholds of crossing distance between patches. Protecting patches that are close together, and especially those with proximity to large patches, should benefit biodiversity.

Technical Methods

The largest areas of high-quality habitat can be identified from basic acreage tabulations from the unprotected modern habitat layer. Identifying areas that are less isolated was done informally, though it could be automated using the near tool or similar proximity analysis in GIS. Large patches over 50 ha were selected and identified in a separate layer. **[Identified automatically and quantified]**

c Protect existing rare habitat types on landscape. [EDGE_EXISITING_UNPROTECTED_PRIORITY_RARE].

Scientific Rationale

There are several habitat types historically present in the Delta that now exist in in very small acreages. Interior dune, alkali seasonal wetlands, oak woodlands and willow thickets all have suffered net areal losses of more than 95 percent (SFEI-ASC 2014). Considering such steep declines, these habitat types should be a priority for protection.

Technical Methods

Rare habitats were identified using simple selection of the above-described habitat types from the unprotected modern habitat type layer. **[Identified automatically and quantified]**

d Protect existing habitat within current tidal-terrestrial transition zone. [EDGE_EXISITING_UNPROTECTED_PRIOITY_TZONE].

Scientific Rationale

The tidal-terrestrial transition zone supports valuable environmental gradients, high biodiversity and other ecological benefits, such as capacity for marsh migration with SLR (SFEI-ASC 2016). Understanding where existing marshes and terrestrial habitat are located in relation to each other is key to developing adequate protection and support for these functions. An upland buffer of 290 m from intertidal elevation is predicted to provide a suite of ecological functions (Semlitsch and Bodie 2003). This functional width likely would provide a variety of benefits, including a sufficient distance for movement and resources for herpetofauna and some small mammals (see A Delta Renewed).

Technical Methods

Areas that can contribute to the t-zone are identified by intersecting a layer of existing modern edge habitats with the polygon of the current intertidal elevation buffered by 290 m (explained above) to determine what lands can serve as current or future tidal-terrestrial transition zone. **[Identified automatically and quantified]**

2. Identify opportunities for restoration of "new" areas of terrestrial habitat types. [EDGE_OPPORTUNITY].

Scientific Rationale

In addition to protecting existing habitats, consideration should be given to restoration potential of lands converted to human land uses from historical habitat types. Potential for edge opportunities are based on historical ecological evidence, but consideration of contemporary variables, such as groundwater and soil conditions, is also important.

Technical Methods

The total opportunity area for protection and restoration was identified by taking the "edge" area described in the intro to Section IV, intersecting it with the modern habitats layer from A Delta Transformed (SFEI-ASC 2014) and dissolving adjacent parcels. The remaining landscape block(s) represents the contiguous areas that can be further analyzed for regional opportunities for specific conservation priorities. **[Identified automatically and quantified]**

Specific priorities include:

a Identify opportunities for restoring habitat connectivity. [EDGE_OPPORTUNITY_CONNECT].

Scientific Rationale

Supporting connectivity is a fundamental goal of conservation efforts, to allow for movement and dispersal between geographic areas for species, and to link and sustain physical processes across gradients and landscapes that support various habitat types and biodiversity generally. Connectivity can be both defined in a variety of ways, as expressed below in the following components.

Technical Methods

Connectivity can be measured in a number of different ways, dependent on the definition. Connectivity here is defined mostly in terms of structural connectivity and thus is measured close proximity of habitats, or based on California Department of Fish and Wildlife (CDFW) landscape connectivity analyses (see below). However, more detailed assessments of opportunity types were not given here due to some constraints explained in later text various sections.

Areas to prioritize include:

i. ***Those that increase intra- and inter-habitat connectivity among existing modern habitats and protected areas. [EDGE_OPPORTUNITY_PROTECT].***

Scientific Rationale

Connecting existing habitats can provide key corridors to movement and exchange of resources between patches, as well as supporting biodiversity generally by expanding cumulative patch size in of itself.

Prioritizing connections among and to protected habitats is of obvious additional importance, as restoration and habitat quality improvements are often most accessible and feasible on these lands.

Terrestrial habitat types are inherently a mosaic and depend on management and many environmental gradients. As these gradients will change with changing climate and management, promoting within-habitat connectivity is a valuable goal, particularly for species that depend on rare, fragmented habitat types such as interior dunes or vernal pools. Increasing habitat connectivity between different habitat types is important for species that might rely on resources specific to multiple different habitat types or vegetation communities.

These areas were identified manually, though software programs or more sophisticated tools such as Linkage Mapper could identify connectivity opportunities in a more thorough and finer-grained way in future analyses.

Technical Methods

These areas were identified manually, by observing areas with protected or existing habitat in close proximity. More sophisticated technical tools such as Linkage Mapper could identify connectivity opportunities in a more thorough and finer-grained way in future analyses [Identified manually].

ii. ***Those that contribute to tidal-terrestrial transition zones and facilitate marsh migration [EDGE_OPPORTUNITY_CONNECT_TZONE].***

Scientific Rationale

This category is highlighted to explicitly call out acquiring lands to preserve for future t-zone habitat— lands between both existing terrestrial habitats and protected areas and future projected marshes, rather than just protecting existing transition zone habitat. See also Section IV, 2a under edge wildlife and Section I, 2f under native fish and marsh wildlife.

For edge habitat species, this tidal-terrestrial transition zone should extend a significant distance upslope of the marsh. This specific distance may depend on desired ecological functions, but 1,000 m was used to identify of terrestrial habitat beyond marshes provides a threshold that encompasses many ecological functions, inclusive of distance within which the amount of emergent wetland most strongly influences heron and egret colony site selection, but also encompassing the smaller threshold distances that provide ecological functions including the terrestrial buffer preserved upslope of wetlands to maintain terrestrial resources for herpetofauna (290 m), the distance California voles move into terrestrial habitats from marshes during the wet season (100 m), the preferred distance between Tree swallow nesting sites and foraging sites in the marsh (100 m), and the distance that California ground squirrels leave terrestrial habitats into marshes to forage (20 m) (SFEI-ASC 2016).

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. This analysis should be prioritized during future phases of this work. [Not identified]

iii. Those that enhance connectivity to areas outside of the Delta, e.g., to Suisun Marsh, Coast Range, Foothills. [EDGE_OPPORTUNITY_CONNECT_REGIONAL].

Scientific Rationale

Large-scale connectivity is important for movement of large mammals such as bobcats, whose home ranges average around 2,638 ha (Zezulak and Schwab 1979 in CWHR), and connections of populations, as well as exchange of materials and resources on the scale of the watershed or larger. These connections are also expected to facilitate the movement of plants and animals both towards and away from the Delta over multiple time-scales (from seasonal to decadal).

Technical Methods

Areas where habitat restoration might improve regional connectivity from a conservation biology perspective are identified using CDFW's essential connectivity (ECA) layer (from Spencer et al. 2010), which identifies areas of important connections throughout the state. Intersecting polygons of the CDFW layer with the undeveloped, unprotected terrestrial edge layer yields suggested areas of protection/restoration that match with broader aims of connectivity. Also, areas of regional connectivity may also be identified by general landscape observation of the relationship between the Delta periphery and surrounding large landscape habitat blocks. **[Identified automatically and quantified]**

iv. Those that enhance connectivity within, to and among natural landscape blocks from existing habitat and protected areas. [EDGE_OPPORTUNITY_CONNECT_BLOCKS].

Scientific Rationale

Connectivity to and among large scale landscape blocks is important for the same reasons described in Section IV, 2a-iii.

Technical Methods

Areas for connectivity within, to and among blocks can be identified in two ways:

1) Areas of large natural landscape blocks sourced from CDFW's Essential Connectivity project (Spencer et al. 2010) can be intersected with the footprint of undeveloped, unprotected areas, to highlight all of the areas that currently represent contiguous landscape blocks but are not protected, and could potentially benefit from restoration.

2) As an additional, finer-scale form of analysis, these blocks could be buffered based on the average distance separating nests of a focal terrestrial species, such as Swainson's hawk, 1,450 m based on averages reported in Dunkle 1977 and Bloom 1980 in CDFW's California Wildlife Habitat Relationships (CHWR). All areas that intersect the undeveloped, unprotected footprint, then, are areas that could be restored and improved to link closely to these large landscape blocks.

CDFW's ECA layer set is comprised in part of existing natural landscape blocks, which is based on an Ecological Condition Index (Davis et al. 2003, 2006 and Spencer et al. 2010), using inputs of degree of land conversion, residential housing, roads, forest structure, degree of conservation protection, mapped critical habitat and endemism hotspots. [Not identified]

b Restoring rare or lost habitat types [EDGE_OPPORTUNITY_RARE].

Scientific Rationale

There are several habitat types historically present in the Delta that now exist in in very small acreages. Interior dune, alkali seasonal wetlands, oak woodlands and willow thickets all have suffered net areal losses of more than 95 percent (SFEI-ASC 2014). Considering these steep declines, these habitat types should be a priority for restoration. Historical land cover type is a helpful consideration for where restoration of these rare habitat types might be possible; however, groundwater depletion, surface hydrological modification, agricultural practices and other management choices may have altered precise opportunities for recreation of some of these habitat types.

Technical Methods

These opportunities were mapped simply by selecting the modern habitat types layer and intersecting it with the edge opportunity layer described in the introduction of Section IV, 2. **[Identified automatically and quantified]**

c Restoring undeveloped areas, particularly areas large enough to support desired ecosystem functions (derived from Delta Renewed guidelines). [EDGE_OPPORTUNITY_LARGE_METRICS].

Scientific Rationale

As discussed above, the footprint we developed for terrestrial restoration corresponds to lands higher than 3.78 m NAVD88 (an approximate current MHHW elevation plus 1.8 m [6 ft] SLR), minus portions that are currently urbanized. Thus, these areas are those that are potentially appropriate for long-term terrestrial habitat restoration with projected future climatic and SLR changes.

However, more specific consideration of species requirements and other ecological thresholds related to habitat patch size can help further prioritize areas for restoration. The Delta Renewed report provides landscape configuration guidelines for certain terrestrial edge habitat types, including grasslands, vernal pools and wet meadow/seasonal wetland. For instance: 129 ha represents the minimum recommended giant garter snake patch size for wet meadow/seasonal wetlands, 336 ha for a minimum Swainson’s hawk home-range size in grasslands, and 1,375 ha for a breeding population of tiger salamanders for vernal pools.

Further literature review gives a few suggested benefits for other habitat types, such as 5.2 ha as a potential home range size for kit foxes, representing use of habitat types such as alkali seasonal wetland complexes (Koopman et al. 2000); 2 ha representing habitat benefits for butterfly species associated with small patches, representing stabilized interior dune habitat (Longcore and Osborne 2015), and 2,638 ha for home range size of bobcats, representing use of habitat types such as oak woodland (Zezulak and Schwab 1979 in CWHR).

This is not to say that ecological benefits will not be provided in smaller areas -- ecological functions can be provided even in small patches surrounded by agricultural land use (e.g., Tscharntke et al. 2002). Further, these exact home ranges are not perfect estimates, as they are approximations or averages from the literature, and actual use of the landscape, even among restored patches, will of course depend on local resource availability, existing population distributions, barriers to movement in the landscape, and other similar factors. Also, the mosaic of habitat types should be acknowledged; many species utilize multiple habitat types within their home ranges and thus it is difficult to establish precisely the appropriate acreages per species per habitat type.

Nonetheless, the metrics suggested above provide rough outlines of potential benefits provided for various restoration targets. These metrics help establish potential approximate floors for consideration of a suite of ecological functions that benefit a variety of taxa.

For rare habitats (terrestrial habitats with greater than 95 percent loss) with relatively small historical distribution in total (i.e., stabilized interior dune, alkali seasonal wetland complex and willow thickets), it is recommended that restoration target acreages and distribution targets match general historical conditions. The acreage of interior dune scrub and alkali seasonal wetland complex were small enough in extent historically that exact thresholds for restoration may not be necessary—all potentially suitable areas should probably be considered for restoration.

For habitats with larger historical distribution (i.e., wet meadow/seasonal wetland, oak woodland and grassland), it is recommended that the targets listed above are referenced to set objectives for habitat restoration and/or land acquisition.

Oak woodland in particular is nearly entirely gone from the Delta periphery. However, large swaths of undeveloped land exist in the eastern Delta north of Stockton where much of oak woodlands were historically located. Opportunities for agroforestry or integration with rangelands could also exist in this area (see Habitat and Connectivity for Edge Wildlife section for more on this topic). Consideration should also be given to the connectivity and feasibility, as discussed previously.

Technical Methods

These opportunities described above were identified using simple acreage tabulations from the historical ecology map layers from A Delta Transformed (SFEI-ASC 2014) overlaid with the undeveloped, above-SLR projection opportunity layer. The intersection of the “opportunity layer” described in the beginning of the edge section and the historical ecology layer yields at a coarse scale opportunities for restoration. Applying the ecological metrics listed above, this intersected layer was then subsetted by selecting contiguous areas of the given patch size thresholds. This produced a set of data layers demonstrating areas where restoration to match historical habitat types is still possible, and where these opportunities are contiguous and sizeable enough to potentially support ecological functions of interest. For instance, these analyses showed where areas in which large enough vernal pools could be restored in the historical footprint to support a breeding population of tiger salamanders. **[Identified automatically and quantified]**

d Integrate ecological processes with human land uses by: [EDGE_HUMANLU].

Scientific Rationale

Urban land and agricultural cover now take up roughly four-fifths of the contemporary legal Delta, representing the largest land use cover types by acreage. These human-dominated land uses provide opportunities to integrate support for ecological functions into the landscape. Restoring terrestrial corridors in urban and agricultural areas, such as greenways and the upland portions of riparian areas, can provide ecological connectivity for terrestrial species. Restoring edge habitats in urban areas can be targeted in urban open spaces, such as public parks. Recovering some functions of oak woodlands, grasslands and willow thickets can be achieved through street tree and green infrastructure programs. Further, integrating and expanding wildlife-friendly agricultural practices can provide a variety of benefits for fauna in a somewhat hostile matrix environment.

Technical Methods

Due to time constraints, a detailed assessment of these opportunity types has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

Adaptation Potential

Scientific Rationale

SFEI-ASC (2014) defines "wildlife adaptation potential" as the potential ability of native plant and animal populations to adapt to changing conditions. Wildlife adaptation potential encompasses adjusting to new or increased disturbances and stressors, utilizing newly available resources, and moving as the locations of suitable conditions shift. Wildlife adaptation potential is particularly important in the face of climate change, SLR, and changing water management in the Delta. Species distributions, habitat associations, and life-history strategies are likely to change over time in ways that are difficult to predict.

Promoting wildlife adaptation potential at the landscape scale can help to manage for an uncertain future. Adaptation potential is supported by large wildlife populations with high genetic and phenotypic diversity, which in turn generally require extensive, heterogeneous habitats. The ability of species to move along physical gradients (in elevation, salinity, and other parameters) as conditions change requires habitat connectivity.

An important next step in this analysis is to identify areas of potential climate refugia within the Delta. The Delta in general is of particular conservation importance regionally, as due its lower elevation and closer proximity to the coast and potential future greater cooling breezes, temperatures are likely to rise less quickly than other parts of the Central Valley. In this way, the Delta may serve as an area of temperature refuge for many species (Cal-Adapt 2017, Council 2018). Factors that may aid in identifying climate refugia potentially include areas of environmental stability, microclimate heterogeneity, large size, connectivity/accessibility (Keppler 2015). Some more particular examples of such types of places include areas with canopy cover that can buffer local temperature maximums and areas near or in large deep lakes have a high heat capacity and will likely warm more slowly. Areas with inputs to groundwater recharge are also of high importance, as they provide lower stream temperature somewhat independently of air temperature. Valleys may harbor cool air pockets and inversions, unlinked to regional circulation processes, while terrain with significant variability in topography can provide many different microclimates, some that are expected to experience slower rates of change in key environmental variables with climate change (e.g., Morelli et al. 2016).

Considering these thoughts, riparian restoration may be a priority given its high adaptation potential and strong natural resilience (Seavy et al. 2009). Also highlighted is the importance of considering and prioritizing management of flood basins and historical lakes. Finally, locating areas of groundwater recharge potential can provide multiple functions including refugia. Areas with high topographic variability, can be formed to some degree by vernal pool habitat restoration (see Section IV, 1c and 2b). South-facing slopes and valleys can be found more in terrestrial habitat types, such as the relatively unprotected rangelands at the edge of the east Delta.

More analysis needs to be done to more comprehensively identify these opportunities, with a basis for improving the other ecological functions discussed here. Sections I-IV can be used for the focal taxa groups to formulate and evaluate planning for climate adaptation and refugia planning. Example frameworks for how to conceptualize and manage climate refugia can be found in such papers as Keppler et al. 2015 and Morelli et al. 2016.

Technical Methods

While adaptation potential was not specifically analyzed for this effort, this effort did identify opportunities to support large and connected habitat types for tidal marsh, riparian, and terrestrial habitats. Analysis for adaptation potential might consider how opportunities span across specific environmental gradients including salinity and microclimate. Protecting species at the edge of their range may be important for maintaining species across environmental gradients. For Delta species where distinct populations have been identified (e.g. Chinook salmon, giant garter snake) opportunities should be across areas that support these different populations.

Analyses for determining climate refugia are addressed to some degree in other sections but were not evaluated comprehensively at this time due to time constraints. **[Not identified]**

Productivity

Scientific Rationale

Primary production, the supply of food, energy, and biochemicals provided by plants and algae, helps to set the capacity of ecosystems to support wildlife populations. One key goal of wetland restoration in the Delta is to increase primary production in the Delta to provide additional food resources for native fish. A study currently in progress is using data from the Delta Landscapes Project to estimate how landscape change has altered primary production (Cloern et al. 2016). Insights from that project may be useful for better understanding the effects of wetland size and configuration on the magnitude of primary production.

Technical Methods

While we did not analyze opportunities to increase primary production in this effort, some of the opportunities highlighted to support other ecological functions would increase the amount of primary production or its export from wetland to open water habitat (e.g., large marsh areas, channel reconfiguration). Primary production in the Delta is influenced by the hydrodynamics of the Delta as well as wetland extent and configuration. In, addition, identifying beneficial actions to support primary production is complicated by invasive species (aquatic plants and clams) that affect whether increases in primary production will benefit target native species. **[Not identified]**

Biodiversity

Scientific Rationale

A Delta Renewed (SFEI-ASC 2016) recommends a systematic conservation planning approach for biodiversity which considers: communities and ecosystems, abiotic and physical features, and key species likely to be missed by the first two categories. In the steps above, in our approach for life-history support functions, we address communities and ecosystems, and physical features. Here we address the final category: key species likely to be missed by the first two categories. These include imperiled, threatened, or endangered species; endemic species; focal species that are area-limited, dispersal-limited, resource limited, or limited by ecological process (e.g., natural flow regime); and keystone species. These analyses generally consider existing species distributions based on direct observations or modelling, though in some cases, they also consider support for potential habitat.

1. Identify areas that are critical to species covered in the Bay Delta Conservation Plan (ICF International 2013).

Technical Methods

We considered species covered in the Bay Delta Conservation Plan (BDCP) and used maps in the species accounts from Appendix 2A of BDCP to make sure areas critical to key species are being covered. For species found in only a limited portion of the Delta these areas are identified. As part of the BDCP appendix, these maps were not georeferenced and thus not available in the GIS layers package. **[Identified manually]**

a Identify areas of modeled vernal pool habitat, or degraded vernal pool habitat [BIODIVERSITY_VERNAL_POOL].

Scientific Rationale

Vernal pool associated "covered species" that could be supported in these areas include Legenere, Heckard's peppergrass, dwarf downingia, Boggs Lake hedge-hyssop, alkali milk-vetch, vernal pool tadpole shrimp, vernal pool fairy shrimp, mid-valley fairy shrimp, longhorn fairy shrimp, Conservancy fairy shrimp, California linderiella, and California tiger salamander.

b Identify areas in the west Delta that could support species not found in other parts of the Delta. [BIODIVERSITY_WEST_DELTA].

Scientific Rationale

The range of several species found in the lower estuary extend into the westernmost part of the Delta. These species include soft bird's beak, Suisun song sparrow, California least tern, and salt marsh harvest mouse. In addition to increasing biodiversity within the Delta, preserving these areas may also support the adaptation potential of these species by maintaining habitat at the edge of their ranges, and supporting their distribution across important environmental gradients (e.g., salinity, temperature).

c Identify areas of the south Delta that support unique riparian species. [BIODIVERSITY_SOUTH_RIPARIAN].

Scientific Rationale

Species supported in this area include slough thistle, Delta button celery, riparian woodrat, riparian brush rabbit.

d Identify areas of the northwest Delta periphery that support covered species. [BIODIVERSITY_SOUTHWEST_TERRESTRIAL].

Scientific Rationale

Species supported in this area include red-legged frog, San Joaquin kit fox, also: heartscale, brittlescale. Note that there's overlap with potential vernal pool areas.

e Identify areas important for covered species with limited ranges within the Delta that are not already covered by the steps above. [BIODIVERSITY_SKULLCAP], [BIODIVERSITY_LEAST_BELLS_VIREO], [BIODIVERSITY_CARQUINEZ_GOLDENBUSH].

Scientific Rationale

Covered species with limited ranges in the Delta that are not already covered by the steps above include: side flowering skullcap, Least Bell's vireo and Carquinez goldenbush.

f Identify other patterns in supporting covered species in the Delta [BIODIVERSITY_CENTRAL_MARSH].

Scientific Rationale

Several covered species had fairly broad distributions within the Delta that somewhat align with Central Delta Public Lands corridor: Suisun marsh aster, Delta tule pea, Delta mudwort, Mason's lilaeopsis, western pond turtle, Yellow-breasted chat, Black rail.

2. Identify opportunities for very large areas of continuous habitat to support wide-ranging endemic and generalist species, including habitat diversity at a large scale. Restoration and protection of large natural areas should be coordinated in Sections I-VII to provide contiguous, large scale blocs of diverse habitat that provide support for and integrate across ecological functions.

Scientific Rationale

Very large areas could support wide ranging species that use multiple habitat types, including tule elk (Cobb 2010). These areas would provide additional benefits to wildlife at the population and community level, as larger areas are associated with larger population sizes and more complex community structure, supporting increased biodiversity relative to smaller areas (Rosenzweig 1995, Peterson et al. 1998). Habitat heterogeneity, in combination with large areas, can also help support biodiversity (Carpenter and Brock 2004, Standish et al. 2014). In the Delta, this would mean coordinating large contiguous restoration and protection of habitats across gradients, from wetland to terrestrial, lowland to upland, upstream to downstream, that can provide the greatest gradients of physical processes and thus support for diversity of habitat types, communities, and ultimately species. Other recommendations in this document relate to this goal, such as prioritizing areas in the tidal-fluvial zone, areas where marsh is adjacent to riparian, areas where marsh is adjacent to undeveloped lands that could support tidal-terrestrial transition zone and marsh migration space, and protecting and restoring areas near existing habitats.

Technical Methods

Due to time constraints, a detailed assessment of this opportunity type has not yet been conducted. This analysis should be prioritized during future phases of this work. **[Not identified]**

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APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Attachment 1 – Opportunities Table

Delta Plan Amendments

May 2020

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Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region

Region#[1]	Name[2]	Opportunity Types (codes)[3]	Description[4]	Ecological Restoration[5]	Ecological Restoration Notes[5]
Central Delta					
1	Central Delta	[MARSH_REMNANTS] [BIODIVERSITY_CENTRAL_MARSH]	**Protect and enhance existing remnant marshes** ↳ examples labeled with 1A	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [BIODIVERSITY_CENTRAL_MARSH]	**Restore marshes in subsided areas** ↳ minimally subsided areas at least 100 ha in size include parts of eastern Liberty Island and parts of western Twitchell Island ↳ minimally subsided areas at least 500 ha in size include Sherman Lake and Frank's Tract	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
		[SALMON_REARING_NETWORK] [BIODIVERSITY_CENTRAL_MARSH] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Restore a network of large (>500 ha), well-distributed, and hydrologically connected wetlands capable of supporting juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region ↳ sites here should be tidal marshes with dendritic channel networks ↳ substantial reverse subsidence efforts will be required to bring land surfaces up to intertidal elevation ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ existing sites include Sherman Marsh ↳ planned sites include Sherman Island [1D], Twitchell Island [1C], and Frank's Tract [1H] ↳ a strategically located site would still be needed in the general vicinity of the Mokelumne-Georgiana confluence (e.g., South end of Staten Island [1B]), which is also located within a tidal-fluvial transition zone	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
			Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations ↳ at least 4 additional sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, additional sites may not be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects, but potentially include Bouldin Island [1F] and Staten Island [1E] (Staten Island is also located along a tidal-fluvial transition zone)	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
			Between these large nodes consider channel margin improvements to increase the length of vegetated edges (may not require full setbacks) ↳ Channel margin habitat type enhancements between Franks Tract and MWT/Staten Island. ↳ Restore tidal habitats along Seven Mile Slough [1G]	No	Levee modification projects to create channel margin habitat type have reduced ecological integrity and long-term sustainability.

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
1 (contd.)	Central Delta (contd.)	[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ e.g., at Fisherman's Cut [1J] and at Frank's Tract in combination with marsh restoration (to create tidal flows primarily in and out of False River with limited flow through Frank's Tract to Old River) [1I]	No	Reliance on water control diminishes long-term sustainability.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting of hedgerows)	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
27	East Delta	[MARSH_REMNANTS]	**Protect and enhance existing remnant marshes** ↳ examples labeled with [27A]	Yes	
		"[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_TRANGRESSION_SPACE]	**Restore marshes on lands at intertidal elevation** ↳ the area at intertidal elevation in this region is large enough to support a dendritic channel network (>500 ha), is adjacent to remnant blind channel networks, and has extensive undeveloped migration space.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ opportunity to restore a large (>500 ha) marsh in existing minimally subsided area ↳ restoring subsided areas at Brack, Terminous, Rio Blanco, Bishop, Shim, and Wright-Elmwood Tracts could improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development (building off of remnant blind channels)	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
		[RAIL_NETWORK]	**Build on the surrounding network of marshes by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 4 sites would be needed in this region to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Explore potential benefits of channel barriers to re-establish blind channel geometry and hydrodynamics** ↳ e.g., isolating cuts between White Slough and Disappointment Slough **[27D]** and cut between Disappointment Slough and Fourteenmile Slough **[27E]**	No	Reliance on water control diminishes long-term sustainability.

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
27 (contd.)	East Delta	[EDGE_EXISTING_UNPROTECTED] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_LARGE_METRICS]]	**Enhance and expand appropriate terrestrial habitat types (primarily seasonal wetlands and oak woodlands) at upper edge of tidal zone, especially ones with direct connections to restored tidal marshes** ↳ protect any existing terrestrial habitats without protections in place, e.g., along and north of White Slough. ↳ seasonal wetland restoration, particularly in former alkali wetland areas located above the SLR zone with remnant alkali soil types (e.g., near W. Peltier Road east of I5 [27B], near Thornton Road north of Stockton [27C]) ↳ Opportunities for large patches of oak woodland restoration on eastern side.	Yes	
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
19	West Delta	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 19Q	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE]	**Restore marshes on lands at intertidal elevation** ↳ at least 3 sites could support marsh patches larger than 100 ha in size and also feature undeveloped migration space. These include Byron Tract [19J & 19K], eastern Veale Tract [19D], and Eastern Hotchkiss Tract [19C]. Some of these sites are adjacent to remant blind channel networks. All are contiguous with undeveloped migration space. Byron Tract [19J & 19K] is contiguous with existing terrestrial habitat types to form tidal-terrestrial transition zones.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ minimally subsided areas in this region such as north-eastern Hotchkiss Tract [19E], western Veale Tract [19F], Holland Tract [19G], Quimby Island [19H], and Byron Tract [19L] could support marsh patches larger than 500 ha ↳ reverse subsidence in these areas would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development ↳ priority sites include areas around remnant stabilized interior dunes to restore associated marsh-terrestrial transition zones (see below)	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_CONNECT_TZONE]	**Protect, prepare, and, restore SLR accommodation space and tidal-terrestrial transition zones of current and planned marshes** ↳ e.g., areas without urban development above Big Break [19A] and above Dutch Slough [19B]	Yes	
			Restore connections between tributaries and wetlands ↳ potential for spring-fed creeks to deliver sediment to marshes, increase local turbidity, and potentially increase cool-water conditions within wetland complexes; also potential to restore associated seasonal wetlands and woody riparian vegetation ↳ e.g., Marsh Creek [19M], Brushy Creek [19N], Frisk Creek [19O], Kellogg Creek [19P]	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
19 (contd.)	West Delta (contd.)	[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 4 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible less than 4 additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [19S]	No	Reliance on water control diminishes long-term sustainability.
		[BIODIVERSITY_VERNAL_POOL] [BIODIVERSITY_SOUTHWEST_TERRESTRIAL] [EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT] [EDGE_EXISTING_UNPROTECTED_PRIORITY_RARE] [EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_CONNECT_TZONE] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_REGIONAL] [HUMAN_LU]	**Protect and restore terrestrial habitat types** ↳ protect persistent alkali seasonal wetland complexes at Byron and Veale Tracts. ↳ protect wet meadows, large patches of grasslands, and nontidal marshes not currently protected at Bryon and Veale Tracts, including those to connect to larger protected areas, e.g., near Marsh Creek. ↳ protect and restore modeled vernal pool habitat type near [19P], an opportunity expected to support many sensitive species. ↳ perform active restoration to increase extent of and connectivity among terrestrial habitat types. ↳ protect and connect habitat along Antioch urban fringe (waterfront by Carquinez Strait), including rare unprotected dune habitat type and other terrestrial habitat types for multi-benefit urban greening (particularly for t-zone adaptation) e.g., near Lake Alhambra and [19R]. ↳ opportunities to acquire and restore large terrestrial mosaic of habitat types, in part for t-zone connectivity, particularly with large patches of dunes and oak woodlands. ↳ acquire and restore terrestrial habitats types to connect to large landscape blocks (ex. Diablo foothills, Vasco Caves, toward Altamont) from Clifton Court Forebay and Southwest of Old River.	Yes	
		[EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT]	**Restore stabilized interior dune habitat type at remnant sites** ↳ e.g., at eastern Jersey Island [19I], at Dutch Slough [19B], at western Veale Tract [19F] ↳ couple with marsh restoration to create marsh-terrestrial transition zone	Yes (but see note)	Some uncertainty about processes needed to sustain habitat types over long term. Potential for reduced ecological integrity and long-term sustainability.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
31	Southern Central Delta	[MARSH_REMNANTS]	**Protect and enhance existing remnant marshes** ↳ examples labeled with 31A	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
31 (contd.)	Southern Central Delta (contd.)	[SALMON_REARING_NETWORK]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region ↳ in this region these sites should be tidal marshes with dendritic channel networks ↳ substantial reverse subsidence efforts will be required to bring land surfaces up to intertidal elevation ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ strategically located sites would still be needed along Old River and Middle River (e.g., general location of Bacon Island [31B]), along the San Joaquin River, (e.g., general location of Lower Roberts Island [31D]), and near the distributaries' confluence (e.g., general location of Medford Island [31C])	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 7 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 3 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [31E]	No	Reliance on water control diminishes long-term sustainability.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
16	Cache-Sherman Corridor	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 16A	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN]	**Restore marshes in subsided areas** ↳ minimally subsided areas at the northwest end of Brannan Island **[16B]** could support a marsh patch >100 ha and is also adjacent to potential woody riparian vegetation	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
16 (contd.)	Cache-Sherman Corridor (contd.)	[SALMON_REARING_NETWORK]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region, though these are both accounted for in adjacent regions (see Cache Slough Complex and Central Delta Corridor) ↳ sites here should be tidal marshes with dendritic channel networks ↳ substantial reverse subsidence efforts will be required to bring land surfaces up to intertidal elevation in large parts of this region ↳ in the interim period these areas could still provide nontidal marshes for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ existing sites include Sherman Marsh [see 1D] ↳ a strategically located site is still needed in the vicinity of Little Egbert Tract [see 12E]	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 2 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 0-1 additional site would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects, but potentially include Brannan Island [16D], the North side of Sherman Island [16C], or Tomato Slough	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Increase the extent and connectivity of woody riparian vegetation** ↳ opportunities exist in this area to restore hydrologically connected, woody riparian habitats on natural levees	Yes	
		[EDGE_EXISTING_UNPROTECTED_PRIORITY_RARE] [EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT] [EDGE_OPPORTUNITY_REGIONAL]	**Protect and restore edge habitat type fragments off Sacramento mainstem [16E]** ↳ particularly rare alkali seasonal wetland complex fragments, persistent freshwater emergent wetlands and future t-zone habitat fragments ↳ support conservation efforts between Grizzly Island and Sherman Island as part of the local CDFW Essential Connectivity Area [16F]	Yes	
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
30	Sacramento	[EDGE_HUMANLU]	**Urban greening in Sacramento** ↳ in urban settings, aim to promote multi-benefit urban greening, which may involve: 1) restored riparian areas along urban stream corridors for habitat and flood control; 2) restored oak woodland, grassland and willow thickets in public open spaces; 3) green infrastructure using native plants, and oak and riparian tree incorporation into native street tree programs. ↳ protect, restore and connect fragmented terrestrial habitat along Morrison Creek.	No	Urban greening projects generally have reduced ecological integrity and long-term sustainability.
18	Upper Sacramento River	[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN	**Restore marshes on lands at intertidal elevation** ↳ one area at intertidal elevation [18D] is >100 ha in size, has undeveloped migration space, and is adjacent to potential woody riparian vegetation.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
18 (contd.)	Upper Sacramento River (contd.)	[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Restore significant nodes of woody riparian vegetation in "nodes" along the mainstem north of Clarksburg** ↳ target should be riparian vegetation >200 m wide ↳ opportunities to improve woody riparian vegetation at riverside parks ↳ opportunity for more substantial, continuous and wide woody riparian vegetation along Sacramento River between confluences with Shipping Channel and Babel Slough (including Southport Setback Levee Project [18A]) and in vicinity of Sacramento Airport [18B]	Yes	
		[SALMON_REARING_NETWORK]	**Establish a network of large, well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region along the Sacramento River ↳ in this region these sites should be seasonal floodplains	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 2 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, additional sites may not be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
18 (contd.)	Upper Sacramento River (contd.)	[EDGE_EXISTING_UNPROTECTED_PRIOITY_REMNANT] [EDGE_OPPORTUNITY]	**Protect and restore key terrestrial habitat types** ↳ fill gaps in terrestrial connectivity adjacent to Yolo Bypass Essential Connectivity Area. ↳ protect small but persistent wet meadow fragments and large contiguous terrestrial habitat patches near the Yolo/Sacramento county borders	Yes	
			Improve fish passage along river ↳ implement project to allow adult salmonids (and sturgeon) from the Sacramento Deep Water Ship Channel (SDWSC) to pass the channel gates [18C] and enter the Sacramento River	No	Reliance on water control and fish passage structures diminishes long-term sustainability.
7	Sacramento Basin	[MARSH_REMNANTS]	**Protect and enhance existing remnant marshes** ↳ examples labeled with [7F]	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	**Restore marshes on lands at intertidal elevation** ↳ one significant area at intertidal elevation along Snodgrass Slough between MWT and Stone Lakes [7D] is large enough to support a dendritic channel network (>500 ha), is adjacent to a remnant blind channel network, and has undeveloped migration space. ↳ tidal marsh in this area would also enhance connectivity between MWT and Stone Lakes for terrestrial wildlife by minimizing the distance between marshes at these sites ↳ at least 4 sites (all labeled [7G]) could support marsh patches larger than 100 ha in size and also feature undeveloped migration space. Some of these are also adjacent to potential woody riparian vegetation.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
North Delta					
7 (contd.)	Sacramento Basin (contd.)	[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN]	**Restore marshes in subsided areas** ↳ the Pearson District features a large (>500 ha) minimally subsided area around the former site of Secret Lake [7C] that is also adjacent to potential woody riparian vegetation ↳ a >100 ha minimally subsided area is located at [7H]	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[RAIL_NETWORK]	**Build on the surrounding network of marshes by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 1 site would be needed in this region to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [7I]	No	Reliance on water control diminishes long-term sustainability.
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [TOPOGRAPHIC_LOWS_LONG_TERM_INUNDATION]	**Re-establish aspects of flood-basin inundation regime and habitat type features** ↳ one or more water control structure to allow Sacramento River high flows to activate floodplain e.g., [7A] ↳ re-establish woody riparian vegetation on remnant natural levee topography [7B] ↳ re-establish nontidal wetlands at topographic lows from remnant lake topography [7C] ↳ since these actions would divert fish from Sacramento River to the interior Delta, they may be contingent on improving conditions in the interior Delta. Until survival though the interior Delta is at acceptable levels, it might be beneficial to control access from the river to the interior Delta (e.g., through a nonphysical barrier at the head of Georgiana Slough [2T])	No	Reliance on a water control structure diminishes long-term sustainability.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
7 (contd.)	Sacramento Basin (contd.)	[BIODIVERSITY_VERNAL_POOL] [EDGE_EXISTING_UNPROTECTED_PRIOITY_REMNANT] [EDGE_OPPORTUNITY_CONNECT_REGIONAL] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_PROTECT]	**Protect and restore key terrestrial habitat types** ↳ protect existing rare unprotected vernal pool wetland complexes, persistent grasslands and surrounding grassland habitat types near Stone Lakes for broader landscape connections (ex. [7E]). ↳ protect and restore unprotected lands as part of the Stone Lakes ECA and between protected areas for broad scale connectivity. ↳ protect unprotected habitat types along and near Morrison Creek to connect patches of larger protected areas. ↳ opportunities exist in the eastern portion of this planning unit to support large patches of seasonal wet meadows and grasslands.	Yes	
2	Cosumnes-Mokelumne	[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN] [BIODIVERSITY_SKULLCAP]	**Restore marshes on lands at intertidal elevation** ↳ areas that are large enough to potentially support a dendritic channel network (>500 ha) include McCormack-Williamson Tract [2E] and the tract to the southeast [2S]. ↳ both sites are adjacent to natural levee topography that could potentially provide transitions to woody riparian vegetation. ↳ MWT is also adjacent to a remnant blind channel network and, if restored, would enhance connectivity between existing small marsh patches at at Delta Meadows [2G] and MWT's east end [2H]. ↳ the land at intertidal elevation at [2S] is contiguous with undeveloped upland areas. ↳ Delta Meadows and surrounding area supports side-flowering skullcap and mash skullcap [2G]	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Restore marshes in subsided areas** ↳ large minimally subsided areas include the land along Georgiana Slough [2A & 2B], North Mokelumne River [2B & 2C], and South Mokelumne River [2C & 2D] ↳ all of these areas are adjacent to potential woody riparian vegetation and located along tidal-fluvial transition zones ↳ restoring the minimally subsided area east of South Mokelumne River [2D] could improve site hydrology and the potential for coherent dendritic tidal channel network development ↳ restoring the minimally subsided area at the base of MWT [2F] could also improve improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development on the tract	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).
		[SALMON_REARING_NETWORK]	**Restore a network of large (>500 ha), well-distributed, and hydrologically connected wetlands capable of supporting juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region ↳ sites here should be tidal marshes with dendritic channel networks or seasonal floodplains ↳ substantial reverse subsidence efforts would be required to bring land surfaces up to intertidal elevation in portions of the region ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ existing sites include the Cosumnes Preserve ↳ planned sites include the McCormack-Williamson Tract [2E] ↳ a strategically located site would still be needed along the Mokelumne River (e.g., in the vicinity of Thornton [2O])	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
2 (contd.)	Cosumnes-Mokelumne (contd.)	[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 3 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 1 additional site would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
			Prepare existing public lands and acquire other lands along Mokelumne-Cosumnes courses to create a continuous corridor for tidal marsh migration through SLR zone ↳ remove lateral and longitudinal barriers to tidal flows ↳ e.g., elevate I5 [2J], alter or remove levees to restore hydrological connectivity at Grizzly Island [2N]	Yes	
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [2U]	No	Reliance on water control diminishes long-term sustainability.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Remove levee along Mokelumne to restore wide corridor of woody riparian along south edge of tract [2I]** ↳ remnant natural levee topography could be reoccupied to support a woody riparian corridor that is >100 m wide and >5 km long	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Enhance connection between riparian vegetation at MWT and Cosumnes Preserve** ↳ notable gap around I5 (to have gap <100 m, break should not be much wider than highway itself) [2K]	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Work to enhance riparian corridor between large/wide patches at Cosumnes Preserve and Tracy Lake** ↳ artificial levee setbacks to allow riparian vegetation to reoccupy remnant natural levee topography (200- 600 m wide corridor) [2O]	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Enhance connectivity between woody riparian vegetation of Cosumnes Preserve and Mokelumne River** ↳ levee setbacks to allow riparian vegetation to reoccupy remnant natural levee topography on west edge of Cosumnes River Mitigation Bank [2L] ↳ upstream connection to Mokelumne River at Cosumnes Floodplain Mitigation Bank [2M] ↳ similarly, connect terrestrial lands along Dry Creek.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
2 (contd.)	Cosumnes-Mokelumne (contd.)	[EDGE_EXISTING_UNPROTECTED] [EDGE_OPPORTUNITY_CONNECT_REGIONAL] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_PROTECT]	**Restore and expand woody riparian, nontidal marshes, seasonal wetlands and nearby terrestrial habitat types along Cosumnes River [2R]** ↳ continuous transitions from perennial to seasonal wetlands ↳ low-stature seasonal wetlands for long-term crane roosting (outside of tidal zone) ↳ protect and connect existing wet meadow/seasonal wetland fragments to larger protected areas near and off the Cosumnes. ↳ acquire, restore and connect terrestrial habitat types as part of the Cosumnes area Essential Connectivity Area and large landscape blocks to the northeast. ↳ restore large historical willow thicket habitat type in the proximity of [2R]. ↳ opportunities exist to restore large patches of oak woodland habitat type in undeveloped areas on the eastern edge of this region.	Yes	
		[EDGE_OPPORTUNITY]	**Re-oak upland areas** ↳ in agricultural areas plant oaks for hedgerows, shade trees, landscaping ↳ dedicated oak savannah restoration in protected areas (e.g., McFarland Unit [2Q] and Grizzly Island [2P])	Mixed	
17	Lower Sacramento River & Distributaries	[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	**Restore marshes on lands at intertidal elevation** ↳ at least 2 sites (both labeled [17K]) could support marshes larger than 500 ha. Both also feature some undeveloped migration space and are adjacent to potential woody riparian vegetation.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN]	**Restore marshes in subsided areas** ↳ large (>500 ha) and minimally subsided areas are located at Ryer Island, the margins of Grand Island, and Shutter Island ↳ these areas are adjacent to potential woody riparian vegetation	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[SALMON_REARING_NETWORK] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region ↳ in this region these sites should be tidal marshes with dendritic channel networks or seasonal floodplains ↳ substantial reverse subsidence efforts would be required to bring land surfaces up to intertidal elevation in large parts of region ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ planned sites include Prospect Island (degrade levee on west side [17G], construct new cross-levee [17H]) ↳ strategically located sites would still be needed in the general vicinity of the Elk Slough confluence [17F], Sutter Island [17I], and Grand Island [17J] ↳ the Sutter Island [17I] and Grand Island [17J] sites are both located along tidal-fluvial transition zones	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for carbon sequestration and limiting subsidence), would not qualify (minimal ecological integrity, minimal long-term sustainability).

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
17 (contd.)	Lower	[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 7 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 3 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [EDGE_OPPORTUNITY_CONNECT_REGIONAL] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Reconnect natural levees to distributaries to create wide and functional woody riparian corridors** ↳ e.g., at Miner Slough along east side of Prospect [17A]: based on historical ecology, riparian habitat types grade from 100+ m wide at N end of Prospect to emergent wetlands at S end ↳ e.g along East-West portion of Miner [17B]: some existing narrow riparian on inside of levee. ↳ e.g along Sutter [17C]: existing narrow riparian on inside of levee, none wide. ↳ e.g along Elk [17D]: existing narrow riparian on inside and outside of levee, none wide. Historically 300+ m. Functional riparian habitat types would require reconnection of Elk to Sacramento River [17F]. ↳ e.g along Babel Slough at historical splay [17E]: protect and improve remnant oaks on sediment splay near Reamer Farms, expand towards Sacramento ↳ particularly to match local Essential Connectivity Area (areas discussed above, also along mainstem Sacramento and along Winchester Lake).	Yes	
			Elsewhere explore opportunities for wildlife-friendly agriculture to improve habitat and connectivity for riparian wildlife and to improve water quality along key migratory corridors for fish ↳ agricultural re-oaking or hedgerows might increase connectivity between Reamer Farms and Elk Slough ↳ best practices to improve water quality very important in this area because it is a key fish corridor	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
10	Yolo Bypass	[MARSH_REMNANTS]	**Protect and enhance existing unprotected remnant marshes** ↳ examples labeled with [10L]	Yes	
			Increase the extent, duration, and frequency of Bypass inundation and improve fish passage as called for in the Yolo Plan ↳ Lower Elkhorn and Sacramento Bypass levee setbacks and Sacramento Bypass Weir Extension [10A] ↳ Upper Elkhorn levee setback [10B] ↳ Tule Canal riparian and instream restoration [10B] ↳ Fremont Weir extension and improved fish passage [10C] ↳ Wallace Weir improvements [10D] ↳ Lisbon Weir improvements [10E]	No	Reliance on water control and fish passage structures diminishes long-term sustainability.

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
10 (contd.)	Yolo Bypass	[SALMON_REARING_NETWORK]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 4 sites needed within this region ↳ in this region these sites should be tidal marshes with dendritic channel networks or seasonal floodplains ↳ substantial reverse subsidence efforts would be required to bring land surfaces up to intertidal elevation in large parts of region ↳ in the interim period these areas could still provide nontidal marsh for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ existing sites located at Liberty Island ↳ planned sites include Lower Yolo [10K] ↳ strategically located sites would still be needed along the length of the Bypass	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 9 sites would be needed in this region. Counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 6 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Increase the extent and connectivity of woody riparian vegetation** ↳ opportunities exist at north end of this area to restore hydrologically connected woody riparian habitats on natural levees of Sacramento River	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [BIODIVERSITY_LEAST_BELLS_VIREO]	**Improve functioning of eastside tributaries (e.g., Cache Creek [10G], Willow Slough [10H], Willow Slough Bypass [10I], and Putah Creek [10J])** ↳ improve connection of creeks with wetlands, increasing extent, duration, and frequency of associated inundation ↳ improve protection of lands along South Fork Putah Creek to enhance connectivity and floodplain management capacity. ↳ promote associated habitat types at creek mouths, including nontidal wetlands and willow thickets ↳ opportunity to restore woody riparian habitats on remnant natural levees along Putah Creek ↳ opportunity expected to help support Least Bell's Vireo, observed [10P]	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
10 (contd.)	Yolo Bypass	[BIODIVERSITY_VERNAL_POOL] [EDGE_EXISTING_UNPROTECTED] [EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT] [EDGE_OPPORTUNITY_CONNECT_REGIONAL] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_LARGE_METRICS]	**Manage Bypass to create additional seasonal and managed wetlands, particular in the transition-zones upslope of perennial wetland habitat types** ↳ protect existing, particularly persistent seasonal wetland habitat types around the protected areas of the Yolo Bypass, ex. [10M]. ↳ protect and connect large terrestrial habitat type fragments around [10I and 10N]. ↳ promote connection of wetlands protection and restoration to promote connectivity mapping to local Essential Connectivity Area. ↳ restore large willow thicket fragments that existed historically, such as on South Fork Putah Creek and Willow Slough. ↳ protect and connect seasonal wet meadow fragments near Cache Creek [10G], and connect protected terrestrial fragments along the mainstem Sacramento. ↳ opportunities for supporting large-scale wet meadow/seasonal wetland restoration towards Davis and west of the Sacramento [10O].	Mixed	Managed wetlands and have reduced ecological integrity and long-term sustainability.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
12	Cache Slough	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ e.g., Watson Hollow marshes near airport/Liberty Island Road [12F], southeast of Calhoun Cut Ecological Preserve [12G], and within Cache Slough [12P]	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE]	**Restore marshes on lands at intertidal elevation** ↳ at least 3 areas of land located at intertidal elevation--including Liberty Farms/Lookout Slough [12A and 12B], Hastings Tract [12C], and Egbert Tract/Little Egbert Tract [12D and 12E]--could support marsh patches larger than 500 ha. These sites are all also adjacent to remnant historical blind channels (Cache Slough and Lindsey Slough) and are contiguous with undeveloped migration space. ↳ one additional site at Peters Pocket [12R] could support a marsh patch larger than 100 ha, is adjacent to remnant historical blind channels, and is contiguous with undeveloped migration space.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Restore marshes in subsided areas** ↳ minimally subsided areas at the lower edge Egbert [12H], Little Egbert [12I], and Hastings [12J] could support a marsh patch >500 ha ↳ restoration of these areas would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development (building off of Lindsey and Cache slough remnant blind channels) ↳ Little Egbert is also adjacent to potential woody riparian vegetation and along the tidal-fluvial transition zone ↳ reverse subsidence at the base of Liberty Farms [12S] could also improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development (building off of the Cache Slough remnant blind channel)	Yes (but see note)	Long-term restoration of marshes at intertidal elevation with dendritic channel networks constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
12 (contd.)	Cache Slough Complex (contd.)	[SALMON_REARING_NETWORK]	**Establish a network of large (>500 ha), well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 1 site needed within this region ↳ in this region these sites should be tidal marshes with dendritic channel networks ↳ substantial reverse subsidence efforts will be required to bring land surfaces up to intertidal elevation in large parts of this region ↳ in the interim period these areas could still provide nontidal marsh habitat type for other species guilds and possibly be managed to subsidize aquatic food webs through water management ↳ a strategically located site is needed in the vicinity of Little Egbert Tract [12E], which intersects migratory pathways along the lower Sacramento River and its distributaries	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 3 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 2 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects, but potentially include sites described under "Restore marshes on lands at intertidal elevation" above	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[BIODIVERSITY_VERNAL_POOL] [BIODIVERSITY_CARQUINEZ_GOLDENBUSH] [EDGE_EXISTING_UNPROTECTED] [EDGE_EXISTING_UNPROTECTED_LARGE] [EDGE_EXISTING_UNPROTECTED_PRIORITY_REMNANT] [EDGE_EXISTING_UNPROTECTED_PRIORITY_TZONE] [EDGE_OPPORTUNITY_CONNECT] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_REGIONAL]	**Enhance and expand seasonal wetlands at upper edge of tidal zone, especially ones with direct connections to tidal marshes** ↳ protect existing terrestrial habitat types without protections in place, e.g., seasonal wetlands, grasslands, and managed wetlands between Calhoun Cut Ecological Preserve and Rio Vista Municipal Airport [12K], grasslands northwest of Duck Slough [12L], large patches of persistent vernal pool and alkali seasonal wetland complex habitat [12O] and assorted potential t-zone areas around ex. [12D, 12G, 12O, 12A] ↳ seasonal wetland restoration and wildlife-friendly agriculture to enhance connectivity between existing and planned habitat type patches, e.g., in spaces between Jepson Prairie, Dickson Creek, Duck Slough, and Lower Yolo [12M]; connect large grassland fragments near Cache Slough and mainstem Sacramento, and spaces between Jepson Prairie, Rio Vista Airport, and River Road [12N]; opportunities for supporting large-scale vernal pool and wet meadow restoration between [12P and 12Q], particularly also to connect to large landscape blocks to the east of Jepson Prairie. ↳ evaluate potential to restore connections between small tributaries and seasonal wetlands, e.g., Watson Hollow, Ulatis Creek network. ↳ expanding seasonal wetlands here could benefit Carquinez goldenrod, which has a population at the Jepson Prairie [12T]	Yes	
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ e.g., Hastings Cut [12O]	No	Reliance on water control diminishes long-term sustainability.

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
29	Netherlands	[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE]	**Restore marshes on lands at intertidal elevation** ↳ this region contains the largest contiguous area of land at intertidal elevation. It greatly exceeds the 500-ha threshold needed to support a dendritic channel network and is adjacent to potential woody riparian vegetation along Elk, Sutter, and Miner Sloughs ↳ opportunity enhanced by presence of Duck Slough, which could potentially be reconnected to Miner Slough to restore tidal flows to portions of tract, including Medora Lake (but would require targeted reverse subsidence for coherent channel network development, see [29A] below)	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ minimally subsided areas at lower edge of the region [29A] could support a marsh patch >500 ha and would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development ↳ the area is also adjacent to potential woody riparian vegetation	Yes (but see note)	Long-term restoration of marshes at intertidal elevation with dendritic channel networks constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[RAIL_NETWORK]	**Build on the surrounding network of marshes by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 1 site would be needed in this region to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
South Delta					
23	Old River-Paradise Cut	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 23E	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	**Restore marshes on lands at intertidal elevation** ↳ at least 2 areas, including Fabian Tract [23F] and across Old River to the south [23G] could support marsh patches larger than 500 ha. Both have connections to undeveloped migration space and are adjacent to potential woody riparian vegetation. ↳ one additional site south of Old River [23H] could support a marsh patch larger than 100 ha, is contiguous with undeveloped migration space, and is adjacent to potential woody riparian vegetation.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
23 (contd.)	Old River-Paradise Cut (contd.)	[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ one very large minimally subsided area also spans the Middle River and San Joaquin River-north regions and could support multiple marsh patches larger than 500 ha ↳ portions of this area are adjacent to potential woody riparian vegetation ↳ reverse subsidence at the lower end of Fabian Tract [23I] and the lower end of Union Island [23J] would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[SALMON_REARING_NETWORK]	**Establish a network of large, well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region ↳ sites here should be tidal marshes with dendritic channel networks and seasonal floodplains ↳ planned sites include the Paradise Cut Bypass [23A] ↳ a strategically located site would still be needed along Old River (e.g., in the vicinity of Fabian Tract [23F])	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 3 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 1 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [23K]	No	Reliance on water control diminishes long-term sustainability.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [BIODIVERSITY_SOUTH_RIPARIAN] [EDGE_OPPORTUNITY_CONNECT_TZONE]	**Increase the extent and connectivity of woody riparian vegetation** ↳ there is a near-complete lack of wide woody riparian vegetation along Paradise Cut between the Southern Pacific Railroad Bridge and head of Union Island [23A]. Smaller, but still prominent gaps in wide woody riparian vegetation can be found at locations marked with [23C]. ↳ prominent gaps in wide woody riparian vegetation can be found between Old River to Mountain House Creek at locations marked with [23D] ↳ opportunities expected to help support riparian brush rabbit, which has been observed near [23A] to [23C] ↳ preserve and protect terrestrial patches near Tom Paine Slough and Paradise Cut to link gradients across future t-zone to woody riparian vegetation.	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
23 (contd.)	Old River-Paradise Cut (contd.)	[EDGE_EXISTING_UNPROTECTED]	**Protect and restore terrestrial habitat types** ↳ protect persistent grassland patches south of Old River. ↳ opportunities for alkali seasonal wetland complex restoration and large patches of wet meadow/seasonal wetland southeast of Clifton Court Forebay.	Yes	
24	Middle River	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 24D	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	**Restore marshes on lands at intertidal elevation** ↳ one very large area at intertidal elevation is shared with the San Joaquin River- North region [24G and 25E] and could support marsh patches larger than 500 ha. This area has connections to undeveloped migration space and is adjacent to potential woody riparian vegetation. ↳ one additional site [24H] could support a marsh patch larger than 100 ha, is also contiguous with undeveloped migration space, and is adjacent to potential woody riparian vegetation.	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN] [SUBSIDED_HYDROLOGIC_BENEFITS]	**Restore marshes in subsided areas** ↳ one very large minimally subsided area also spans the Old River and San Joaquin River-north regions and could support multiple marsh patches larger than 500 ha ↳ portions of this area are adjacent to potential woody riparian vegetation ↳ reverse subsidence on portions of Union Island [24I] and Drexler Tract [24J] would be expected to improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[SALMON_REARING_NETWORK]	**↳ at least 2 sites needed within this region** ↳ sites here should be tidal marshes with dendritic channel networks and seasonal floodplains ↳ strategically located sites would be along Middle River at its head [24C] and downstream in the vicinity of Howard Road [24F] ↳ note the area along the San Joaquin River near the head of Middle River [24C] was identified through CVFPP Conservation Strategy Floodplain Restoration Opportunity Analysis as potential setback levee area	Yes	
		[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 3 sites would be needed in this region. Counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 1 or fewer additional site would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[CHANNEL_RECONFIGURATION]	**Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfiguration of channel cuts** ↳ example channel cuts marked with [24K]	No	Reliance on water control diminishes long-term sustainability.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
24 (contd.)	Middle River (contd.)	[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	**Increase the extent and connectivity of woody riparian vegetations along Middle River** ↳ especially along the north side of Steward Tract **[24A]** and east side of Union Island **[24B]**, where there is very limited wide woody riparian vegetation ↳ opportunities to combine with woody riparian restoration to create marsh-riparian edge	Yes	
			Evaluate head of Old River barrier [24C] operations to identify and then implement the best alternative for maximizing survival of juvenile steelhead and spring-run Chinook salmon emigrating from the San Joaquin River ↳ functional floodplains and riparian vegetation would require flows to be restored along Old River	No	Reliance on water control diminishes long-term sustainability.
24 (contd.)	Middle River (contd.)	[HUMAN_LU]	**Across area practice wildlife-friendly agriculture and best-management practices** ↳ e.g., screen diversions, buffer wetlands, minimize contaminant loads ↳ e.g., improve quality of matrix (e.g., re-oaking in upland agricultural areas, planting hedgerows) ↳ e.g., wildlife-friendly farming for waterbirds ↳ particularly along/near Middle River.	No	Wildlife-friendly farming projects generally have reduced ecological integrity and long-term sustainability.
25	San Joaquin River- North	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with [25C]	Yes	
		[MARSH_INTERTIDAL] [MARSH_INTERTIDAL_LARGE] [MARSH_INTERTIDAL_WITH_MIGRATION_SPACE] [MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Restore marshes on lands at intertidal elevation** ↳ one very large area at intertidal elevation is shared with the Middle River region [25E and 24G] and could support marsh patches larger than 500 ha. This area has connections to undeveloped migration space and is adjacent to potential woody riparian vegetation. ↳ one additional site [25F] could support a marsh patch larger than 100 ha and is also contiguous with undeveloped migration space. ↳ both areas are also located along the San Joaquin River tidal-fluvial transition zone	Yes	
		[MINIMALLY_SUBSIDED_LARGE] [MINIMALLY_SUBSIDED_ADJACENT_TO_RIPARIAN]	**Restore marshes in subsided areas** ↳ one very large minimally subsided area also spans the Old River and Middle River regions and could support multiple marsh patches larger than 500 ha ↳ portions of this area are adjacent to potential woody riparian vegetation	Yes (but see note)	Long-term restoration of marshes at intertidal elevation constitutes ecological restoration. But interim phases alone (tule farming for reverse subsidence) would not qualify (minimal ecological integrity and minimal long-term sustainability).
		[SALMON_REARING_NETWORK]	**Establish a network of large, well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region ↳ sites here should be tidal marshes with dendritic channel networks and seasonal floodplains ↳ strategically located sites would be along the San Joaquin River near the split with Middle River [see 24C] and downstream of Howard Road (in the vicinity of [25F]) ↳ note the area along the San Joaquin River near the head of Middle River [24C] was identified through CVFPP Conservation Strategy Floodplain Restoration Opportunity Analysis as potential setback levee area	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
25 (contd.)	San Joaquin River- North (contd.)	[RAIL_NETWORK]	**Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity for resident marsh wildlife populations** ↳ at least 2 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for above are restored, it is possible only 1 or fewer additional sites would be required to meet standards for marsh connectivity. ↳ if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/subsided areas with managed wetlands ↳ strategic locations ultimately will depend on the location of other marsh restoration projects	Mixed	Managed marshes in disconnected/subsided areas have reduced ecological integrity and long-term sustainability. Specifically, they do not support the natural processes that sustain nontidal marshes and are require extensive long-term human intervention in the form of water management and levee maintenance. If tidal or fluvial connections are re-established sites would be expected to have enhanced ecological integrity and long-term sustainability and would likely qualify as ecological restoration.
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	
		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [BIODIVERSITY_SOUTH_RIPARIAN] [TIDAL_FLUVIAL_TRANSITION_ZONE_HABITAT_IMPROVEMENT]	**Increase the extent and connectivity of woody riparian vegetations along the San Joaquin River between Howard Road and Old River Head** ↳ Howard Road [25A] represents the approximate downstream extent of woody riparian vegetations historically ↳ today there is extremely limited existing wide woody riparian along this reach [25B], which has been identified through CVFPP Conservation Strategy Floodplain Restoration Opportunity Analysis as potential setback levee area ↳ the area is also located along the San Joaquin River tidal-fluvial transition zone ↳ opportunities would be expected to help support riparian brush rabbit, which has been observed near [26B] to [25B]	Yes	
		[EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_TZONE]	**Restore terrestrial habitat types** ↳ opportunities for large alkali seasonal wetland complex restoration east of the San Joaquin River ↳ opportunities for t-zone and floodplain restoration along the San Joaquin	Yes	
26	San Joaquin River- South	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ example labeled with [26C]	Yes	
		[SALMON_REARING_NETWORK]	**Establish a network of large, well-distributed, and hydrologically connected wetlands to support juvenile salmonid rearing and movement** ↳ at least 2 sites needed within this region ↳ sites here should be seasonal floodplains that support a mosaic of woody riparian vegetation, nontidal marsh, and upland seasonal wetlands ↳ majority of reach identified through CVFPP Conservation Strategy Floodplain Restoration Opportunity Analysis as potential setback levee area [26A]	Yes	
		[RIPARIAN_EXISTING_UNPROTECTED_REMNANT] [RIPARIAN_EXISTING_UNPROTECTED_HYDRO_CONNECTED]	**Protect and enhance existing remnant woody riparian patches** ↳ portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected and are in need of legal protection	Yes	

Table 1-1. Opportunities for Landscape-Scale Restoration in the Delta, Organized by Region (contd.)

Region #	Name	Opportunity Types (codes)	Description	Ecological Restoration	Ecological Restoration- Notes
26 (contd.)	San Joaquin River- South (contd.)	[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES] [BIODIVERSITY_SOUTH_RIPARIAN]	**Increase the extent and connectivity of woody riparian vegetation** ↳ prominent gaps in wide woody riparian vegetation can be found at locations marked with [26B] ↳ opportunities expected to help support riparian woodrat population along the Stanislaus River at Caswell State Park [AR1] ↳ opportunities expected to help support riparian brush rabbit, which has been observed near [26A], near [23A] to [23C], and near [26D] to [25B] ↳ opportunities expected to help slough thistle populations observed near [26D], with modeled habitat all along San Joaquin River in this region	Yes	
		[EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_RARE] [EDGE_OPPORTUNITY_LARGE_METRICS] [EDGE_OPPORTUNITY_CONNECT_REGIONAL]	**Restore terrestrial habitat types** ↳ protect and restore large oak woodland habitat type patches, and alkali seasonal wetland fragments adjacent to existing habitat type patches. ↳ opportunities to connect further to large landscape blocks to the south end of 26 towards upstream San Joaquin River.	Yes	
28	Stockton-Lathrop	[MARSH_REMNANTS]	**Protect and restore existing marshes without protections in place** ↳ examples labeled with 28A	Yes	
		[EDGE_HUMANLU] [EDGE_EXISTING_UNPROTECTED_RARE] [EDGE_OPPORTUNITY] [EDGE_OPPORTUNITY_CONNECT_TZONE]	**Urban greening in Stockton-Lathrop** ↳ in urban settings, aim to promote multi-benefit urban greening, which may involve: 1) restored riparian areas along urban stream corridors for habitat and flood control; 2) restored oak woodland, grassland and willow thickets in public open spaces; 3) green infrastructure using native plants, and oak and riparian tree incorporation into native street tree programs. ↳ protect and restore oak woodland habitat around Bear Creek, Calaveras River, Duck Creek and French Camp Slough where possible in urban environment. Consider oak street trees where not possible. ↳ protect seasonal wet meadow and terrestrial habitat type complexes for t-zone capacity, floodplain connectivity and flood protection along Mormon and French Camp Sloughs, protect and connect lands near the junction of French Camp and Walker sloughs. ↳ protect/restore small alkali seasonal wetland complex parcel south of French Slough	No	Urban greening projects generally have reduced ecological integrity and long-term sustainability.

Notes:
[1] Region #'s correspond with those on the Opportunity Map.
[2] Geographic area covered by the Region #.
[3] This field provides codes that link to the Methodology document, which provides the ecological justification for taking steps as well as the technical methods to identify the opportunities.
[4] This column identifies key action items in bold, followed by location guidance for implementing opportunities, restoration considerations and specifications. Numbers in brackets correspond with the locations of spatially explicit opportunities on the Opportunity Map.
[5] These fields indicate whether the described opportunity/opportunities qualify as "ecological restoration" as defined by Suding et al. 2015 (Science Magazine, volume 348, issue 6235). If not, we explain our reasoning in the notes field.

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APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Attachment 2 – Opportunities Map

Delta Plan Amendments

May 2020

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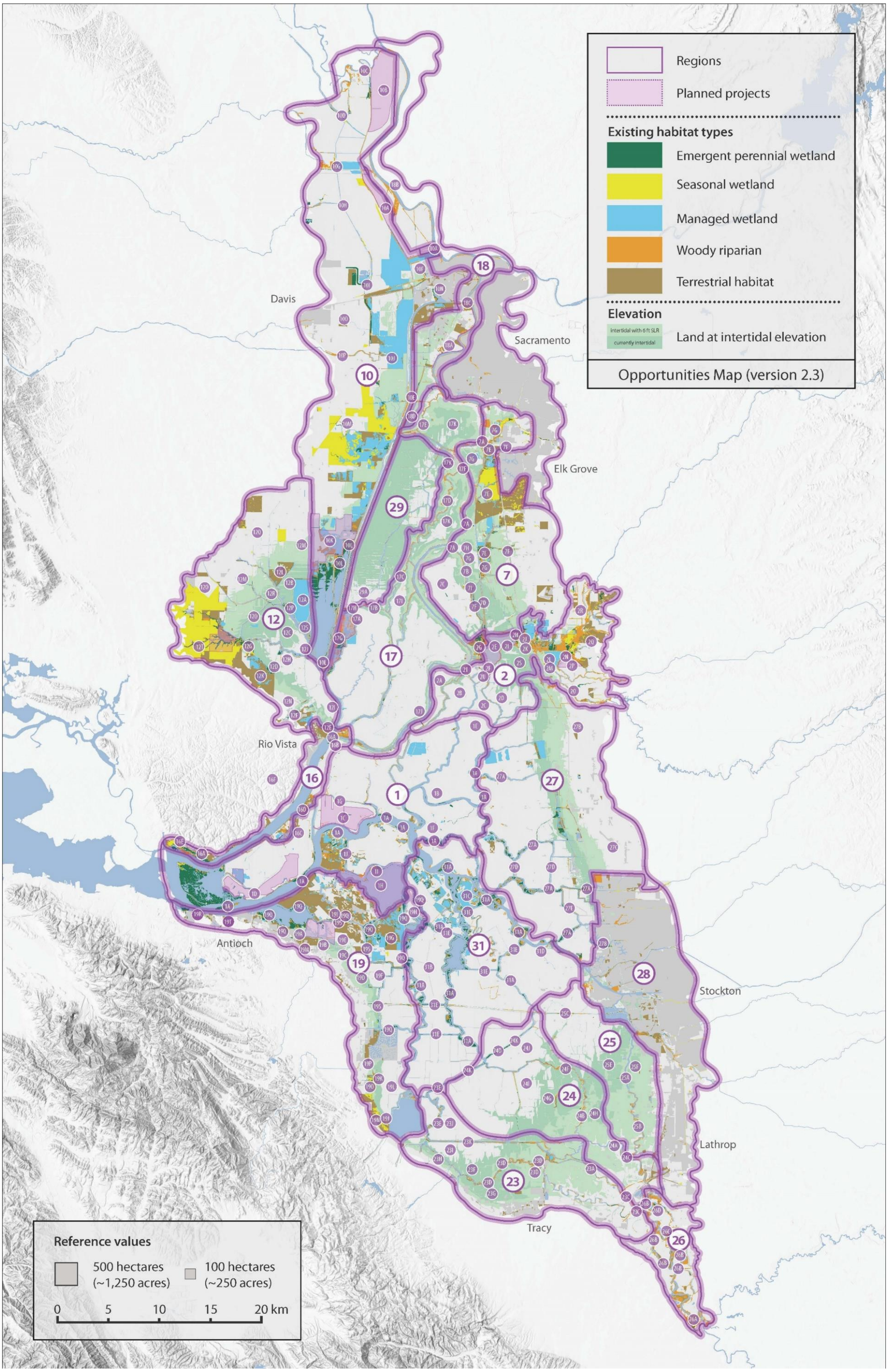

Opportunities Map

This map illustrates the approximate locations of restoration opportunity sites throughout the Delta, corresponding to the restoration opportunities listed in Table 1-1. This map depicts the location of planned restoration projects and opportunities for ecological restoration in the Sacramento-San Joaquin Delta. The map extends from the eastern edge of Suisun Bay on the west, to present-day Stockton in the east; and from Fremont Weir State Wildlife Area in the north, to the lower San Joaquin River in the south.

The existing habitat types depicted include emergent perennial wetland, seasonal wetland, managed wetland, woody riparian, and terrestrial habitat. Existing emergent perennial wetland habitat is concentrated mostly in the central Delta and Yolo Bypass regions. Existing seasonal wetland habitat is concentrated in Cache Slough Complex and Yolo Bypass regions. Existing managed wetland habitat is concentrated in the Yolo Bypass region. Existing woody riparian habitat is concentrated mostly in the Consumnes-Mokelumne region. Existing terrestrial habitat is concentrated in west Delta, Cache Slough Complex, Consumnes-Mokelumne, and Sacramento Basin regions. The map also depicts land that is currently at intertidal elevations, and land that is projected to be at intertidal elevations with future sea level rise.

The map divides the Delta into numbered regions, corresponding to those listed in Table 1-1. The map also depicts opportunities for ecological restoration. These opportunities are labeled using a combination of a number and letter; the number corresponds to the region in which the opportunity is located, and the letter corresponds to the type of project. For example, there are 17 project opportunities shown in the central Delta region. Eight of these are labeled as 1A, representing opportunities to protect and enhance existing remnant marshes. Other project opportunity areas in the central Delta region include 1D, 1C, and 1H which are associated with Sherman Island, Twitchell Island, and Frank's Tract respectively, representing restoration of large, well-distributed, and hydrologically-connected wetlands capable of supporting juvenile salmonid rearing and movement. All other project opportunities depicted in this map are listed in Table 1-1.

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APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Attachment 3 – Opportunities Summary

Delta Plan Amendments

May 2020

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Opportunities Summary v2.3 FINAL DRAFT July 2018

#	step	Step code	Step	Total opportunity acreage (ha)
Habitat and connectivity for native fish and marsh wildlife				
1		[MARSH_REMNANTS]	Identify existing marshes in need of legal protection, especially remnant historical marshes	2,110
2		[MARSH_INTERTIDAL]	Identify areas that are currently at intertidal elevation	33,452
2	a	[MARSH_INTERTIDAL_LARGE_500ha]	Contiguous areas that are large enough to support desired ecological functions (>500 ha)	27,060
2	a	[MARSH_INTERTIDAL_LARGE_100ha]	Contiguous areas that are large enough to support desired ecological functions (>100 ha)	30,703
2	c	[MARSH_INTERTIDAL_REMNANT_BLIND_CHANNEL]	Areas with remnant/existing blind channel networks	8,597
2	e	[MARSH_INTERTIDAL_WITH_MIGRATION_SPACE]	Areas that are adjacent to nonurbanized uplands to provide tidal-terrestrial transition zone functions (including space for marsh migration with SLR)	31,203
2	f	[MARSH_INTERTIDAL_ADJACENT_TO_RIPARIAN]	Areas that are adjacent to potential woody riparian vegetations	24,093
3	a	[MINIMALLY_SUBSIDED_LARGE_100ha]	Areas that are both minimally subsided and large enough to support desired ecological functions (>100 ha)	43,553
3	a	[MINIMALLY_SUBSIDED_LARGE_500ha]	Areas that are both minimally subsided and large enough to support desired ecological functions (>500 ha)	41,447
Habitat and connectivity for riparian wildlife				
2		[RIPARIAN_POTENITAL_ON_NATURAL_LEVEES]	Identify remnant natural levees where woody riparian vegetation (both riparian forest and riparian scrub) could potentially be restored if re-connected to adjacent streams [historical footprint of woody riparian habitats minus existing hydrologically connected woody riparian habitats and areas that have been subject to urban development]	12,928

Opportunities Summary v2.3 FINAL DRAFT July 2018 (contd.)

Step #	Sub-step	Step code	Step	Total opportunity acreage (ha)
Habitat and connectivity for edge wildlife				
1		[EDGE_EXISTING_UNPROTECTED]	Unprotected existing edge habitat - identify existing habitats in need of legal protection (total)	8,222
			Alkali seasonal wetland complex	110
			Grassland	5,901
			Interior dune scrub	1
			Vernal pool complex	1,751
			Wet meadow/Seasonal wetland	459
			Willow thicket	2
			Oak woodland	0
1	a	[EDGE_EXISTING_UNPROTECTED_PRIOITY_REMNANT]	Prioritize remnant edge terrestrial habitats (total)	2,055
			Alkali seasonal wetland complex	90
			Grassland	389
			Stabilized interior dune vegetation	1
			Vernal pool complex	1,395
			Wet meadow/Seasonal wetland	107
			Willow thicket	0
			Oak woodland	73
1	b	[EDGE_EXISTING_UNPROTECTED_PRIOITY_LARGE]	Prioritize large patches (ex. >50 ha) of terrestrial habitats (total)	3,981
			Alkali seasonal wetland complex	0
			Grassland	2,659
			Interior dune scrub	0
			Vernal pool complex	1,321
			Wet meadow/Seasonal wetland	0
			Willow thicket	0
			Oak woodland	0

Opportunities Summary v2.3 FINAL DRAFT July 2018 (contd.)

Step #	Sub-step	Step code	Step	Total opportunity acreage (ha)
Habitat and connectivity for edge wildlife (contd.)				
1	c	[EDGE_EXISTING_UNPROTECTED_PRIOITY_RARE]	Alkali seasonal wetland complex	110
			Interior dune scrub	1
			Willow thicket	2
			Oak woodland	0
1	d	[EDGE_EXISTING_UNPROTECTED_PRIOITY_TZONE]	Prioritize T-zone habitat	27,516
2	aiii.	[EDGE_OPPORTUNITY_CONNECT_REGIONAL]	Within ECA footprint	6,469
2		[EDGE_OPPORTUNITY]	Opportunities: total undeveloped edge acreage (including protected lands and restoration projects)	121,466
2	b	[EDGE_OPPORTUNITY_RARE]	Historical habitat types [now very rare (>95% loss)] (total)	21,034
			Alkali seasonal wetland complex	6,474
			Stabilized interior dune vegetation	427
			Willow thicket	3,382
			Oak woodland	10,751
2	c	[EDGE_OPPORTUNITY_LARGE_METRICS]	Historical habitats with footprints large enough to support DL thresholds (total)	55,023
			Alkali seasonal wetland complex - 5.2 ha for San Joaquin kit fox	2,452
			Grassland - 336 ha for Swainson's hawk	4,646
			Interior dune scrub – 2 ha for butterfly conservation	68
			Vernal pool complex - 1375 ha for tiger salamanders	6,841
			Wet meadow/seasonal wetland - 129 ha for California giant garter snake	26,979
			Willow thicket - 80 ha for Western yellow-billed cuckoo	3,291
			Oak woodland - 2630 ha for bobcat	10,748

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APPENDIX Q3: Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento–San Joaquin Delta

Attachment 4 – GIS Map Package

Delta Plan Amendments

May 2020

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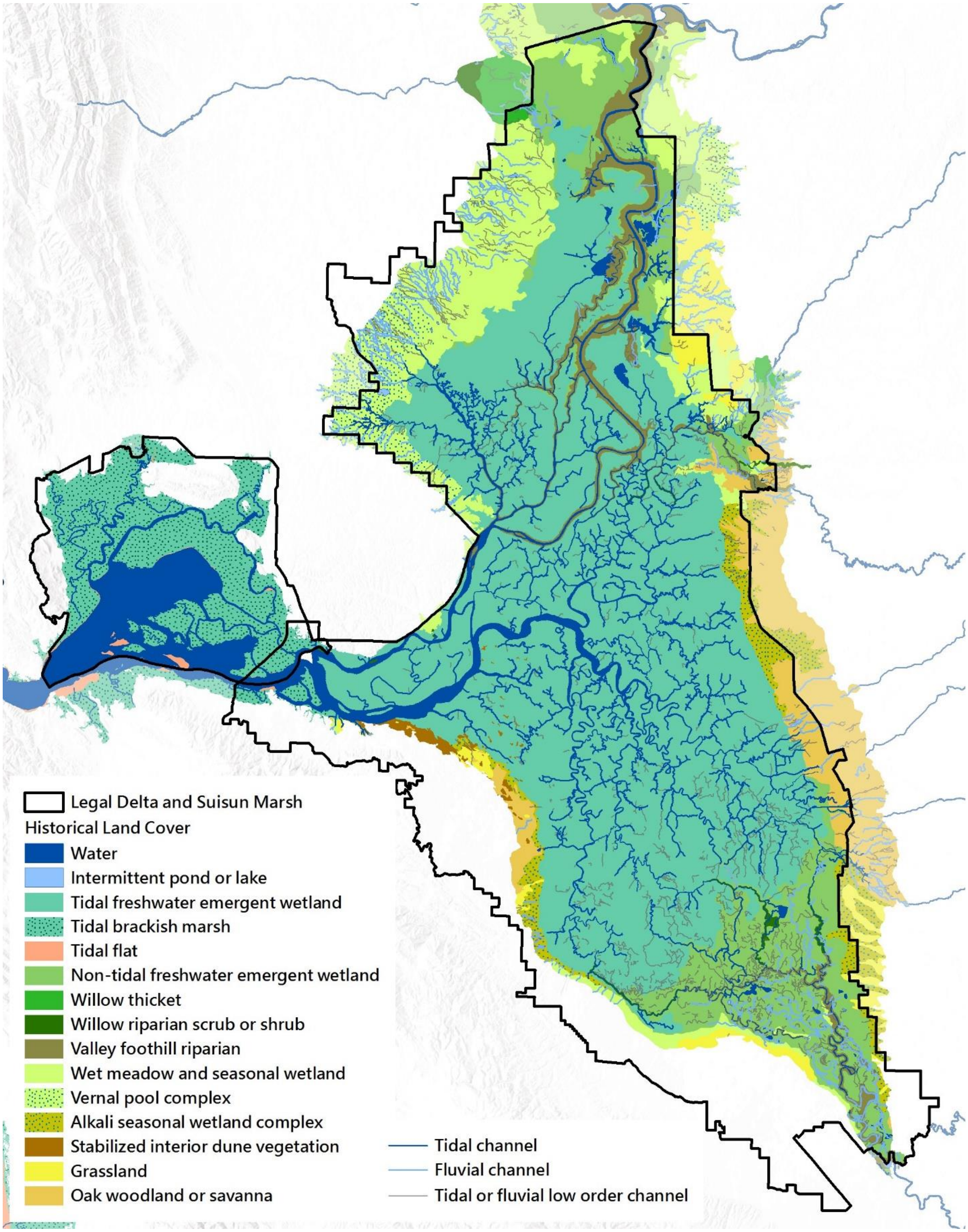

Figure 4-1. Delta Historical Ecology

Figure 4-1. Delta Historical Ecology (contd.)

This map illustrates the Delta's historical (early 1800s) ecology. This map reconstructs the patterns of habitat types in the Delta region prior to the significant modification of the past 160 years. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American Rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. Historical land cover types include water, intermittent pond or lake, tidal freshwater emergent wetland, tidal brackish marsh, tidal flat, nontidal freshwater emergent wetland, willow thicket, willow riparian scrub or shrub, valley foothill riparian, wet meadow and seasonal wetland, vernal pool complex, alkali seasonal wetland complex, stabilized interior dune vegetation, grassland, oak woodland or savanna, tide channel, fluvial channel, and tidal or fluvial low order channel.

This map of the historical Delta (early 1800s) depicts how rivers traversed approximately 400,000 acres of tidal wetlands and other aquatic habitats in the Delta, connecting with several hundred thousand acres of nontidal wetlands and riparian forest. Extensive tidal wetlands and large tidal channels are seen at the central core of the Delta. Riparian forest extends downstream into the tidal Delta along the natural levees of the Sacramento River, and to a certain extent on the San Joaquin and Mokelumne Rivers. To the north and south, tidal wetlands grade into nontidal perennial wetlands. At the upland edge, an array of seasonal wetlands, grasslands, and oak savannas and woodlands occupy positions along the alluvial fans of the rivers and streams that enter the valley. Habitat types in Suisun Marsh were dominated by water, tidal brackish marsh, and tidal flat habitat.

Alternative formats of this map are available upon request.

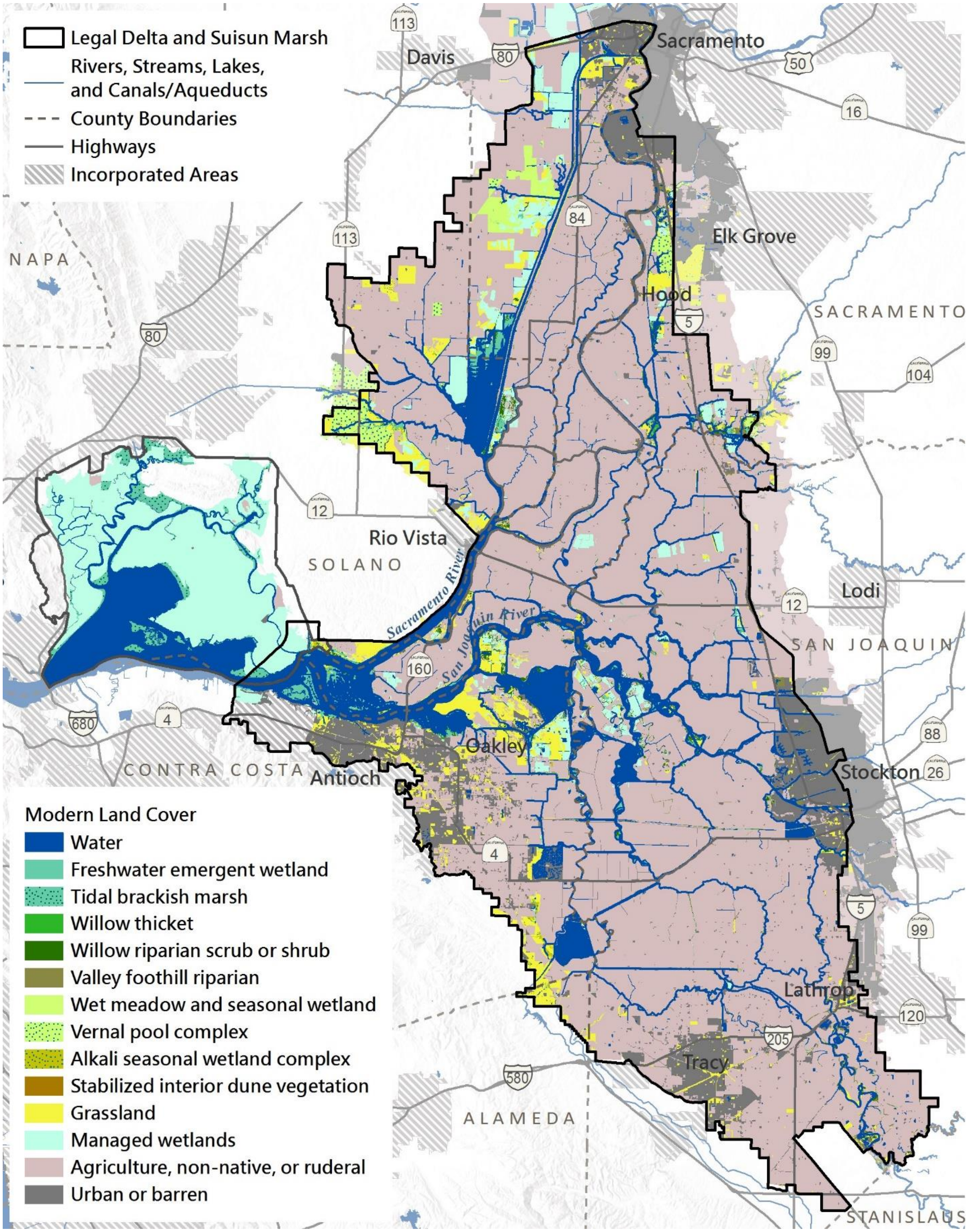

Figure 4-2. Delta Transformed

Figure 4-2. Delta Transformed (contd.)

This map illustrates the ecology of the modern Delta and Suisun Marsh. Compared to Figure 4-1 (map of the Delta's historical ecology), this map illustrates how humans have greatly transformed the Delta's ecology since the 1800's. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. Modern land cover types that are also historical land cover types include water, freshwater emergent wetland, tidal brackish marsh, willow thicket, willow riparian scrub or shrub, valley foothill riparian, wet meadow and seasonal wetland, vernal pool complex, Alkali seasonal wetland complex, stabilized interior dune vegetation, and grassland. Modern land cover types that are not historical land cover types include managed wetlands, agriculture, nonnative, and ruderal cover, and urban or barren cover. Historical land cover types that are not depicted in this map include tidal freshwater emergent wetland, tidal flat, nontidal freshwater emergent wetland, oak woodland and savanna, and channels (tidal, fluvial, and tidal or fluvial low order channels).

The modern state of the Delta ecosystem has been severely affected by the loss of natural communities. Widespread levee construction and large-scale conversion of wetlands to other land uses have severed land-water connections across much of the Delta landscape. As a result, the extent of important seasonal floodplain, tidal wetland, and riparian corridor natural communities has been sharply reduced compared to the pre-reclamation era. The few remaining wetland patches are isolated from one another. The modern Delta landscape is characterized mostly by agriculture, nonnative, or ruderal land cover, rather than the historical distribution of tidal freshwater emergent wetland habitat. Suisun Marsh has been transformed from a tidal brackish marsh to a managed wetland.

Alternative formats of this map are available upon request.

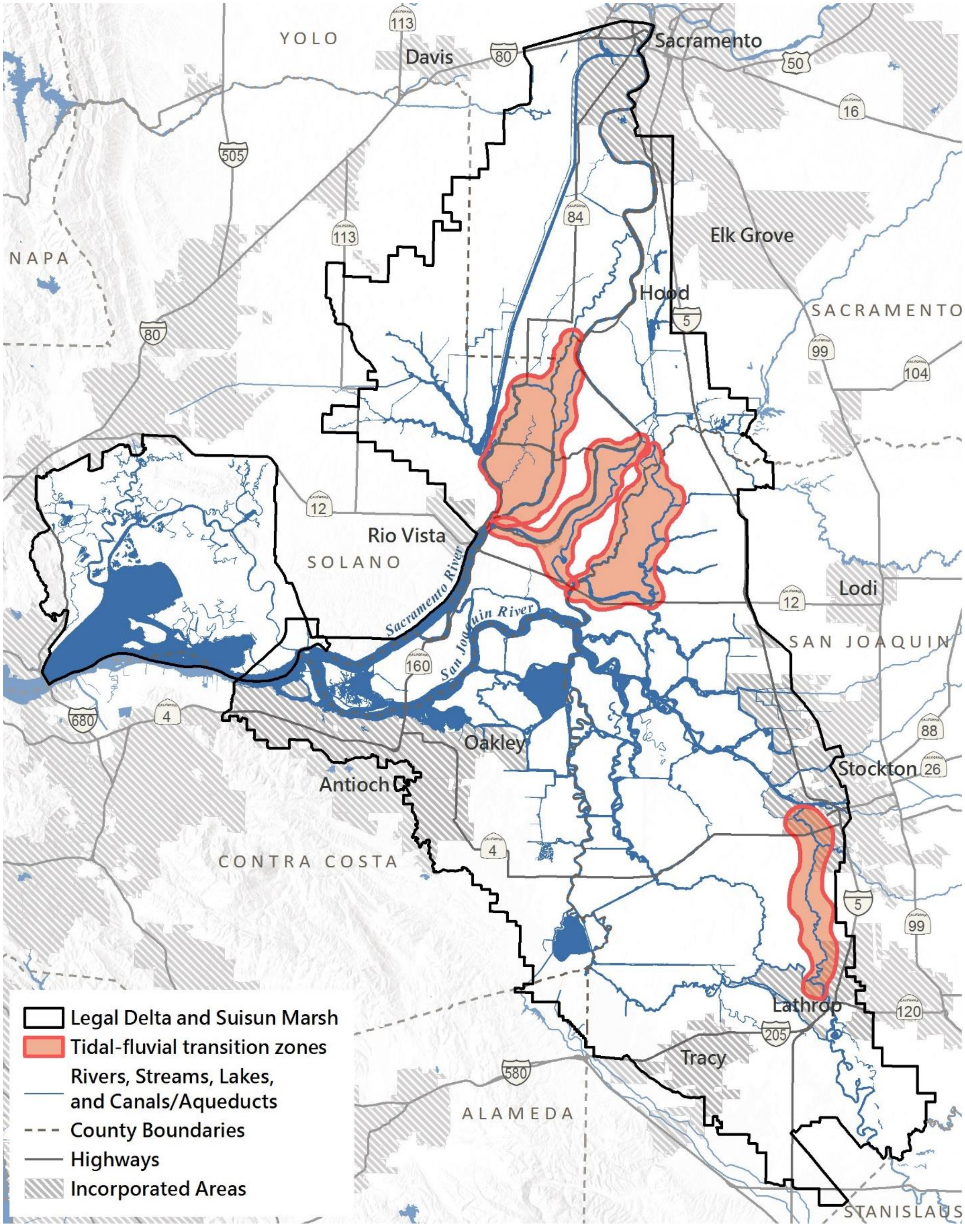

Figure 4-3. Tidal-Fluvial Transition Zone

Figure 4-3. Tidal-Fluvial Transition Zone (contd.)

This map illustrates the tidal-fluvial transition zones within the Delta and Suisun Marsh. Tidal-fluvial transition zones are shown as an orange overlay on a subset of waterways. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American Rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. The rivers, streams, lakes, and canals/aqueducts are shown in solid blue; they are not labeled, except the Sacramento and San Joaquin Rivers. In the north-central Delta, tidal-fluvial transition zones are located along sections of Miner Slough, Steamboat Slough, Sutter Slough, Georgiana Slough, North Fork Mokelumne River, and South Fork Mokelumne River. These tidal-fluvial transition zones include areas of Prospect Island, Ryer Island, Sutter Island, Grand Island, Tyler Island, Staten Island, New Hope Tract, Dead Horse Island, Brannan-Andrus Island, Bouldin Island, Terminous Tract, Canal Ranch Tract, and McCormack Williamson Tract. In the south-east Delta, a tidal-fluvial transition zone exists along the San Joaquin River, extending north to south from Rough and Ready Island to Lanthrop, and includes areas of Rough and Ready Island, Boggs Tract, Middle Roberts Island, Upper Roberts Island, and Stewart Tract.

Alternative formats of this map are available upon request.

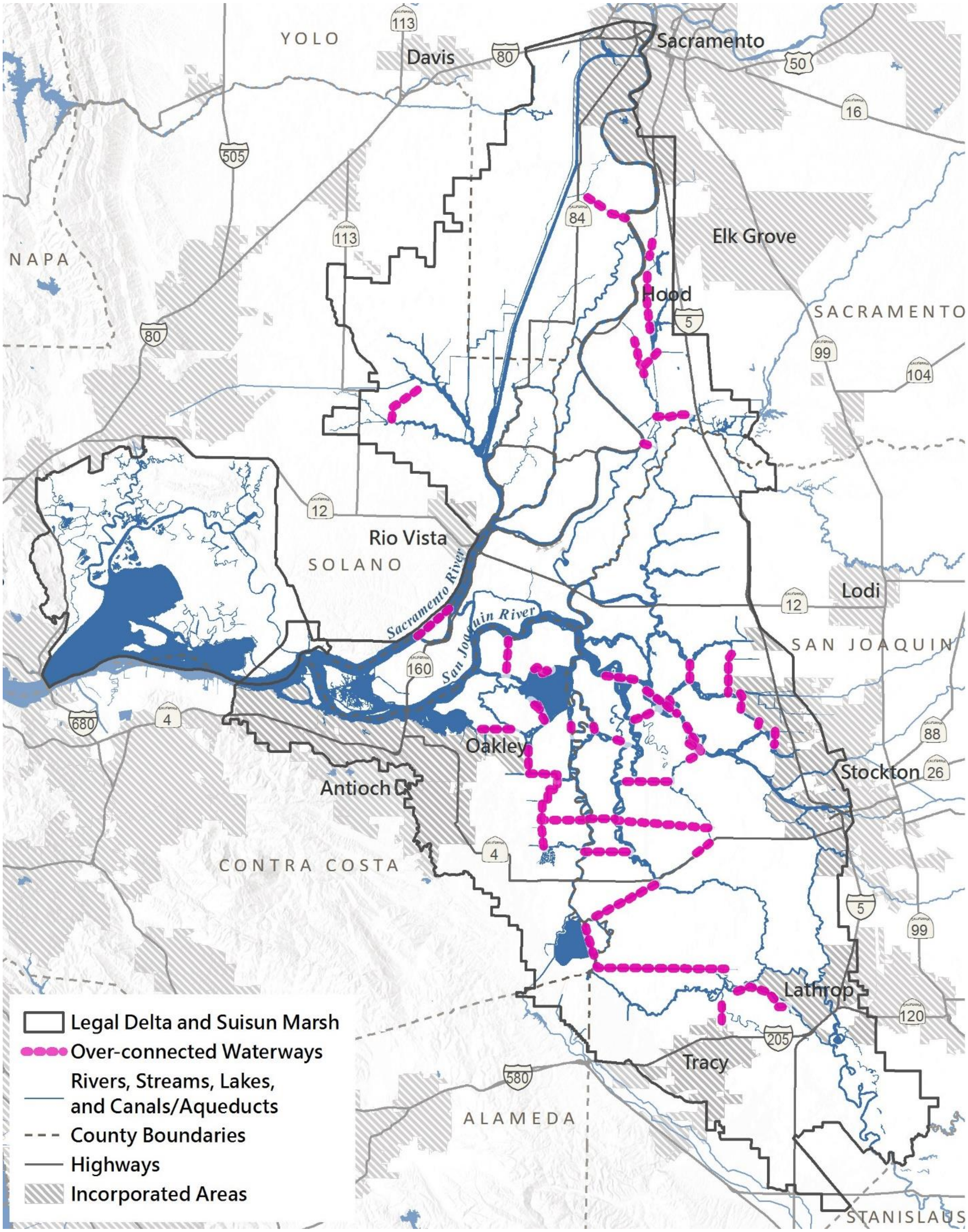

Figure 4-4. Over-Connected Waterways

Figure 4-4. Over-Connected Waterways (contd.)

This map illustrates over-connected waterways within the Delta. Over-connected waterways are highlighted in pink. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American Rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. The rivers, streams, lakes, and canals/aqueducts are shown in solid blue; they are not labeled, except the Sacramento and San Joaquin Rivers. Many artificial hydrologic connections were created during the reclamation era, and are conceived to facilitate the spread of invasive aquatic organisms. This map illustrates the high number of over-connected waterways in the Delta, including sections of Hastings Cut, Winchester Lake, Snodgrass Slough, Lost Sough, Delta Cross Channel, section of Sacramento River near Decker Island, Fishermans Cut, False River and Piper Slough near Franks Tract, Dutch Slough, Holland Cut, section of Old River along Bacon Island, Palm Tract, Fay Island, Orwood Tract, and Woodward Island, Rock Slough, Woodward Canal, West Canal, Victoria Canal, Trapper Slough, Grant Line Canal, Tom Paine Slough, Paradise Cut, Empire Cut, Turner Cut, San Joaquin River Deep Water Ship Channel, Columbia Cut, Disappointment Slough, White Slough, Bear Creek, and Fourteen Mile Slough.

Alternative formats of this map are available upon request.

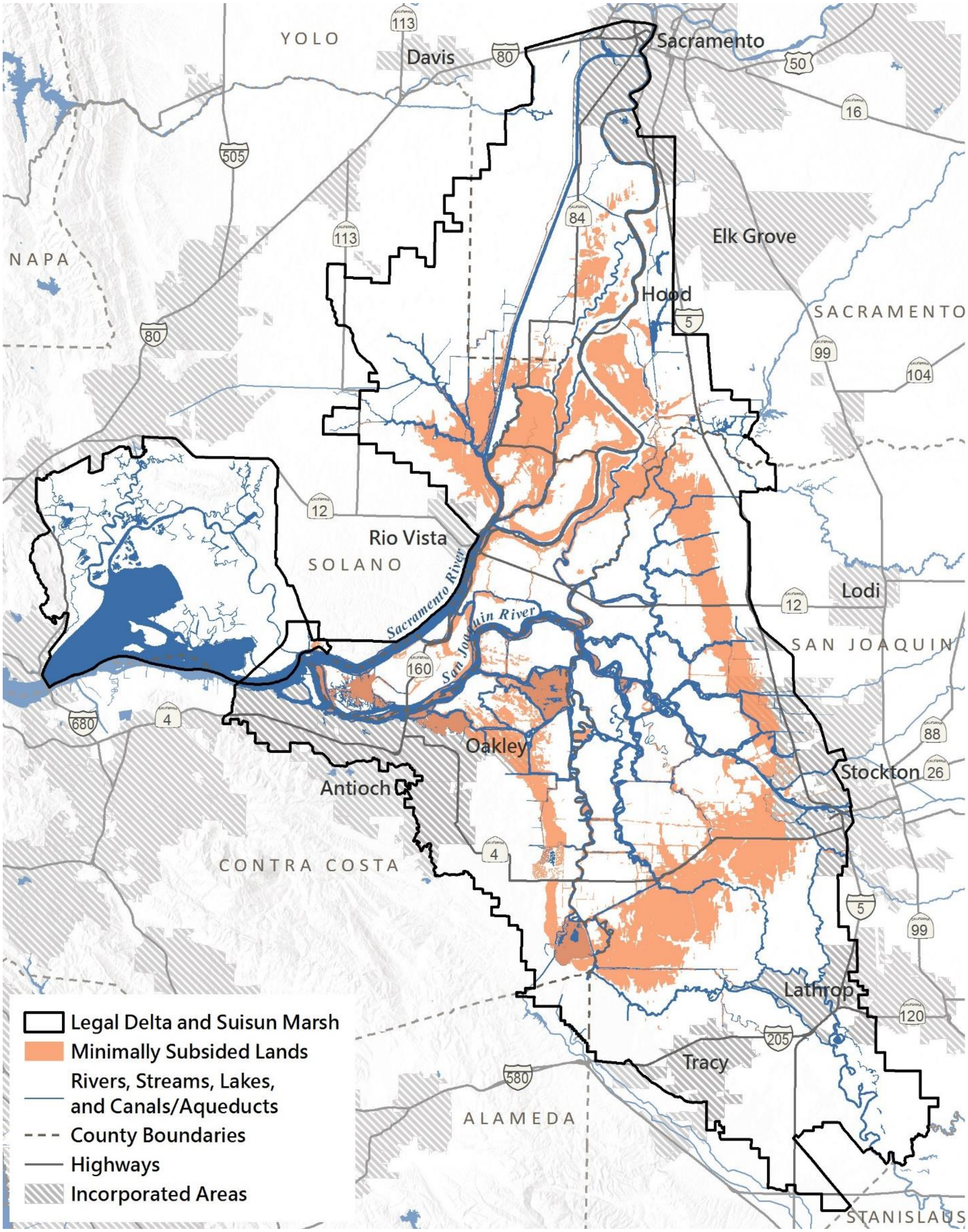

Figure 4-5. Minimally Subsided Lands

Figure 4-5. Minimally Subsided Lands (contd.)

This map depicts areas of minimally subsided lands within the Delta and Suisun Marsh where subsidence reversal activities, ongoing from 2030 to 2100, can produce intertidal elevations by 2100. The map extends from the Carquinez Strait on the west, near present-day Martinez, to present-day Stockton in the east; and from the confluence of the Sacramento and American Rivers in the north, near present-day Sacramento, to the lower San Joaquin River in the south. The rivers, streams, lakes, and canals/aqueducts are shown in solid blue; they are not labeled, except the Sacramento and San Joaquin Rivers. Minimally subsided lands are thought to have the greatest likelihood of achieving intertidal elevations through reverse subsidence efforts. Islands at an appropriate elevation to reach elevations that would support potential intertidal restoration by 2100 include: Drexler Pocket, Honker Lake Tract, Brack Tract, Grand Island, Terminous Tract, Merrit Island, Tyler Island, Pearson District, Sutter Island, Shin Kee Tract, Bishop Tract, Little Egbert Tract, Ehrheardt Club, Ryer Island, Upper Andrus Island, Dead Horse Island, Fay Island, Fabian Tract, Shima Tract, Smith Tract (Lincoln Village), Byron Tract, Lisbon Tract, Cache Hass Area, Rio Blanco Tract, Drexler Tract, Wright-Elmwood Tract, New Hope Tract, Canal Ranch Tract, Hotchkiss Tract, Winter Island, Atlas Tract, Egbert Tract, Netherlands, Prospect Island, Glanville, McCormack-Williamson Tract, Maintenance Area 9, Yolo Bypass, Chipps Island, Mein's Landing, Morrow Island, Grizzly Island, Sunrise Club, Honker Bay, Joice Island, Chipps Island South, Union Island, Middle Roberts Island, Lower Roberts Island, Veale Tract, and Hastings Tract, among others. If subsidence reversal activities are implemented by 2030 in these locations, and these activities continue to accrete the land elevation, land elevations are expected to increase to, and maintain, intertidal elevations by 2100.

Alternative formats of this map are available upon request.

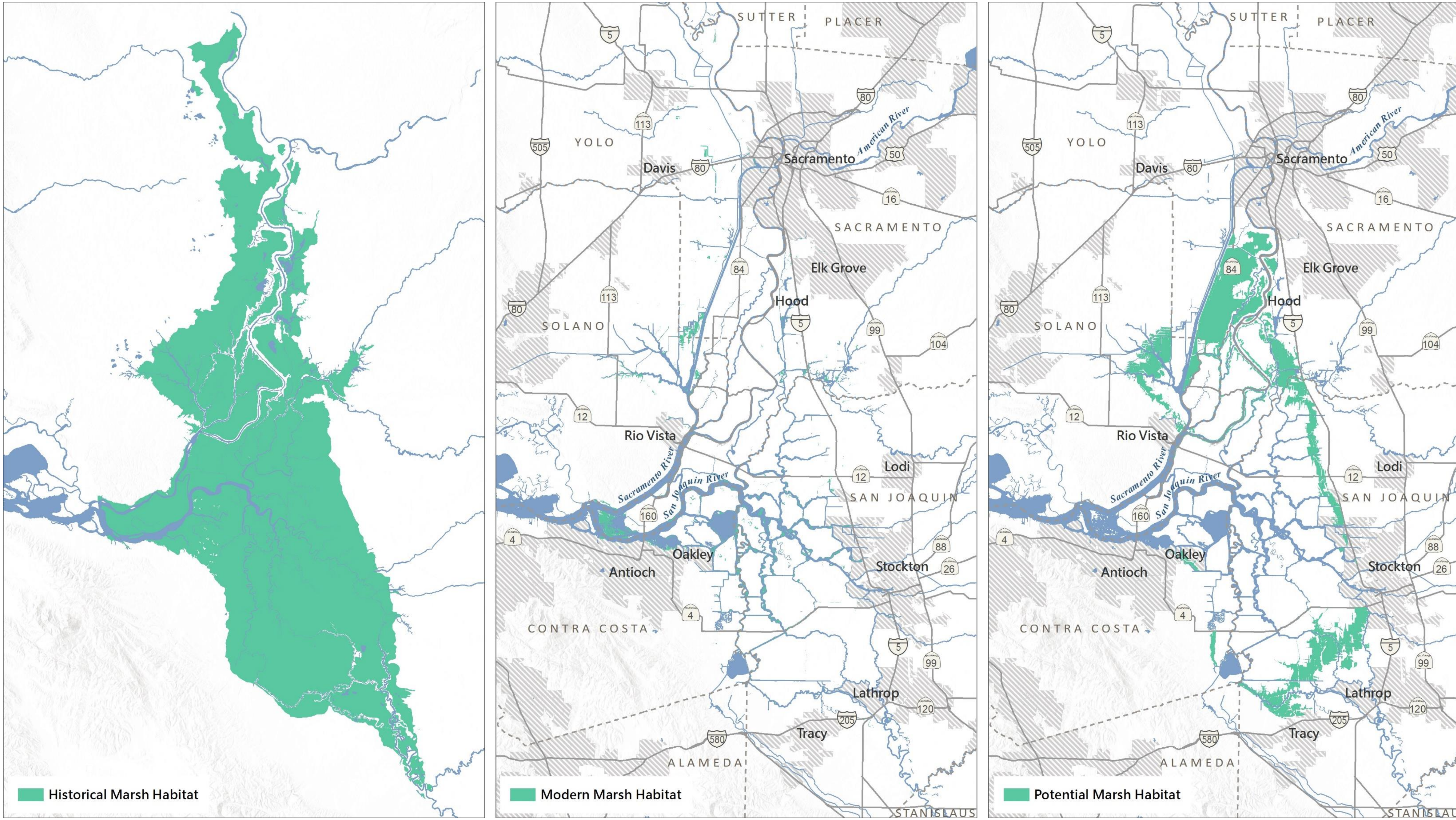

Figure 4-6. Historical, Modern, and Potential Wetland Habitat

Figure 4-6. Historical, Modern, and Potential Wetland Habitat (contd.)

These three side-by-side maps illustrate the historical (early 1800s) marsh habitat, modern (early 2000s) marsh habitat, and potential future marsh habitat within the Delta and Suisun Marsh. The historical Delta map depicts the historical waterways, whereas the modern and potential Delta maps depict the current waterways. The historical Delta map shows that historical marsh habitat extended over the majority of the Delta. The modern Delta map shows that modern marsh habitat extent is limited to scattered patches, with the largest patches located in the Suisun Marsh and western Delta. The map of potential Delta marsh habitat shows that marsh habitat can be greatly expanded throughout the Delta, mostly in the north, east, and southern Delta.

Alternative formats of this map are available upon request.

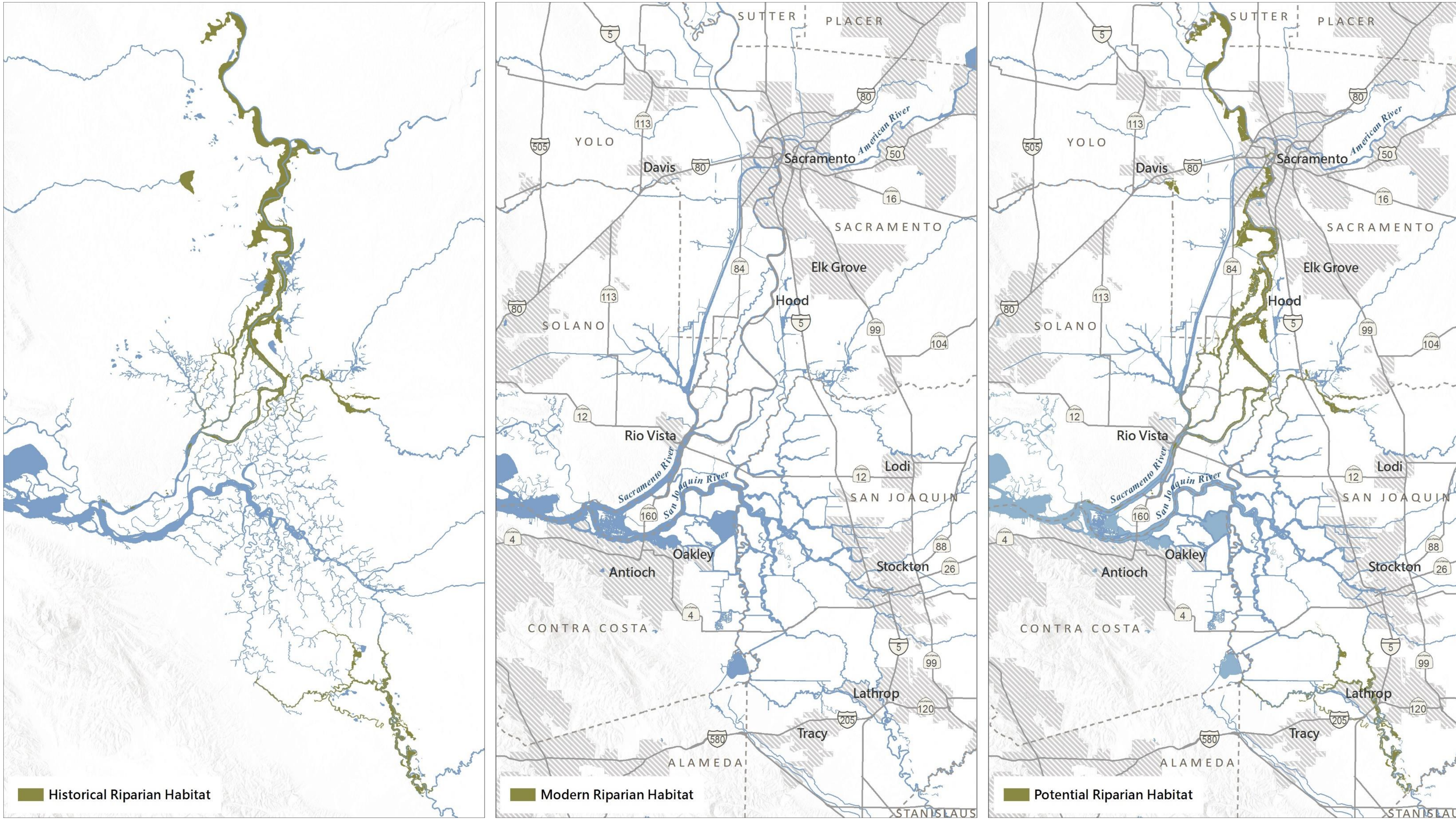

Figure 4-7. Historical, Modern, and Potential Riparian Habitat

Figure 4-7. Historical, Modern, and Potential Riparian Habitat (contd.)

These three side-by-side maps illustrate the historical (early 1800s) riparian habitat, modern (early 2000s) riparian habitat, and potential future riparian habitat within the Delta and Suisun Marsh. The map of historical Delta riparian habitat depicts the historical waterways, whereas the maps of the modern and potential riparian habitat in the Delta depict the current waterways. The map of the historical Delta shows a continuous corridor of riparian habitat, extending downstream into the tidal Delta along the natural levees of the Sacramento River, and to a certain extent on the San Joaquin and Mokelumne Rivers. The modern Delta map depicts a major reduction in the historical riparian habitat extent across the Delta, but also shows the expansion of scattered riparian habitat in the central Delta that historically did not exist. The map of potential riparian habitat (right) shows the potential for riparian habitat to return to a portion of its historical coverage.

Alternative formats of this map are available upon request.

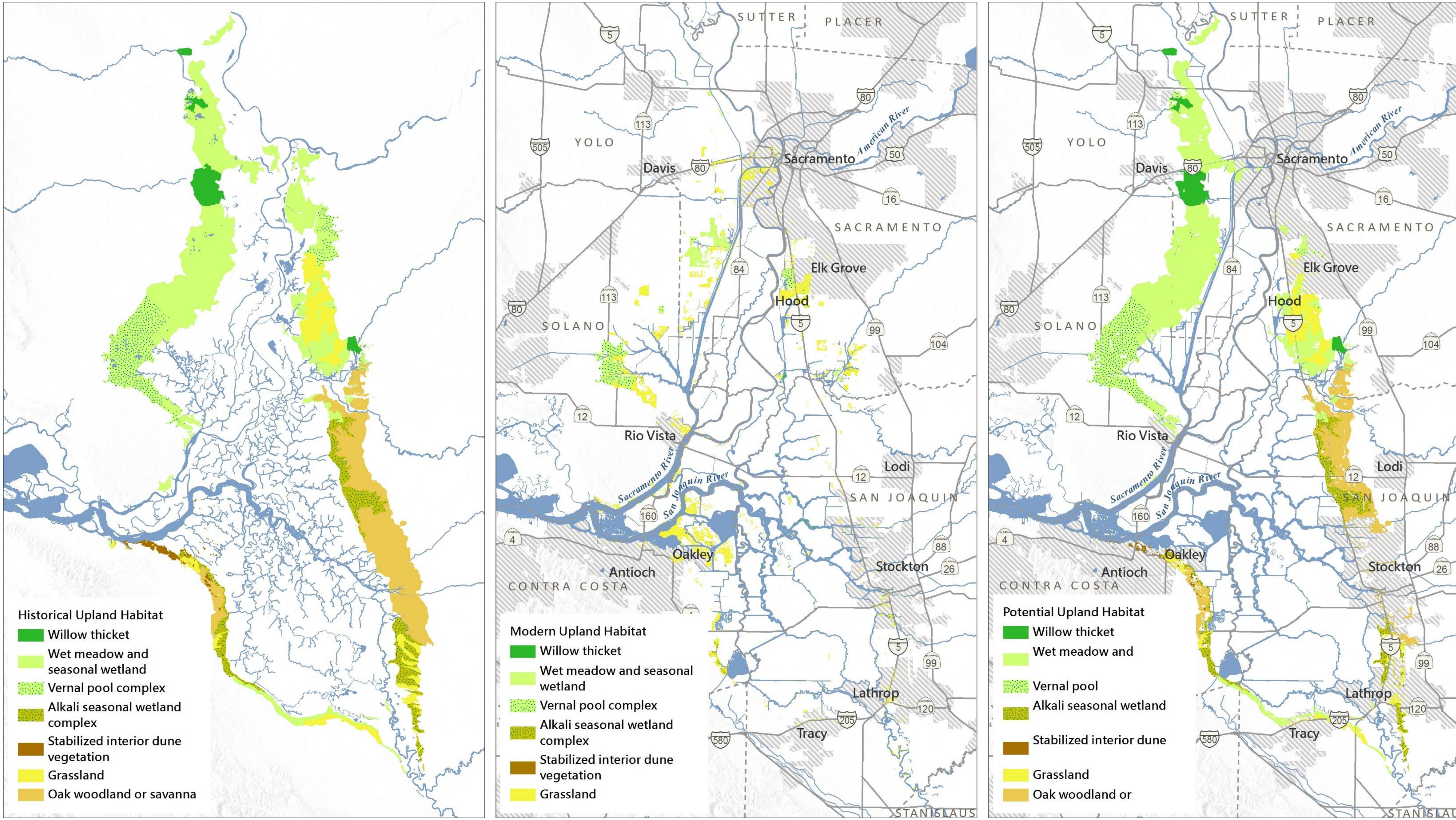

Figure 4-8. Historical, Modern, and Potential Upland Habitat

Figure 4-8. Historical, Modern, and Potential Upland Habitat (cont'd)

These three side-by-side maps illustrate the historical (early 1800s) upland habitat, modern (early 2000s) upland habitat, and potential future upland habitat within the Delta and Suisun Marsh. The map of historical Delta upland habitat depicts the historical waterways, whereas the maps of the modern Delta and potential upland habitat depict the current waterways. Upland habitat types include willow thicket, wet meadow and seasonal wetland, vernal pool complex, alkali seasonal wetland complex, stabilized interior dune vegetation, grassland, and oak woodland or savanna. The map of the historical Delta shows a much greater distribution and diversity of upland habitat compared to the modern Delta. In the historical map, the upland margin of the north Delta was lined primarily by seasonal wetlands, vernal pool complexes, and patches of willow thickets and grassland. The upland margin in the south Delta was lined primarily by alkali seasonal wetland complexes, grassland, and oak woodland or savanna. Upland transitions along the central-western Delta included patches of stabilized interior dune vegetation, alkali seasonal wetlands, grassland, oak woodland and savanna. The central-eastern Delta was characterized by oak woodland and savanna, alkali seasonal wetland complex, and seasonal wetland. The map of modern Delta upland habitat shows a major reduction in the extent of all upland habitat types across the Delta; there are scattered patches of grassland habitat throughout the Delta, and small remaining patches of vernal pool complex and seasonal wetland habitat in the north Delta. The map of potential upland habitat depicts the potential for upland habitat to nearly return to its historical coverage, with the exception of areas that have been urbanized such as south of Sacramento, near Elk Grove, and near Stockton.

Alternative formats of this map are available upon request.

Appendix C
Attachment C-3.6
Proposed Appendix Q4. Conservation and Recovery Plan Target Species

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APPENDIX Q4: Conservation and Recovery Plan Target Species

Delta Plan Amendments

May 2020

For assistance interpreting the content of this document, please contact Delta Stewardship Council staff.

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Contents

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Summary

The Delta Reform Act of 2009 requires that the Delta Plan include measures that promote conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal objectives with respect to doubling salmon populations, re-establishing diverse and biologically appropriate habitats and ecosystem processes, and providing functional corridors for migratory species. Review and synthesis of specific recovery and conservation plans provided a foundation for the development of regional ecosystem restoration targets for the Sacramento-San Joaquin Delta and Suisun Marsh (the Delta). The reviewed plans include:

- CALFED Multi-Species Conservation Strategy (CALFED 2002)
- State Wildlife Action Plan (CDFW 2015)
- Bay Delta Conservation Plan (DWR 2013)
- Central Valley Flood Protection Plan (DWR 2017a, DWR 2017b, DWR 2017c)
- Delta Smelt Resiliency Strategy (CNRA 2016)
- Sacramento Valley Salmon Resiliency Strategy (CNRA 2017)
- San Francisco Estuary and Watershed Science Central Valley Joint Venture Special Edition (DiGaudio et al. 2017, Dybala et al. 2017a, Dybala et al. 2017b, Strum et al. 2017)
- A Delta Transformed: Ecological Functions, Spatial Metrics, and Landscape Changes in the Sacramento-San Joaquin Delta (SFEI-ASC 2014)
- Suisun Marsh Habitat Management, Preservation, and Restoration Plan (Reclamation, USFWS, and California Department of Fish and Game 2013)
- Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (USFWS 2013)
- Recovery Plan for the Giant Garter Snake (USFWS 2017)

Tables 1 to 7 summarize the plant and wildlife species, respectively, targeted by the recovery and conservation plans which are likely to occur within the Sacramento-San Joaquin Delta. While not a complete list of the species associated with the Sacramento-San Joaquin Delta, these tables present a subset of species that are the subject of heightened conservation concern and focused conservation and recovery planning, as of 2018. Achieving the goals and objectives of the recovery and conservation plans would not only be expected to benefit the specific species included in this analysis, but also to provide ancillary benefits to a broader suite of native species which have similar habitat requirements as these species. Subregional restoration planning analyses

should consider the potential restoration of conditions and habitats for each of these species.

The Delta Plan identifies five priority attributes to guide ecosystem restoration actions in the Sacramento-San Joaquin Delta. Actions are prioritized if they: 1) restore ecological processes, 2) are large scale, 3) increase habitat complexity/diversity, 4) improve habitat connectivity, and 5) that benefit at-risk biological communities and species. Generally, these priorities are inherently interrelated. For example, larger-scale projects can greatly benefit certain at-risk species which are particularly susceptible to edge effects and/or that avoid highly fragmented habitat patches. There is an extensive number of at-risk species present in the Sacramento-San Joaquin Delta—many of which are unique to California—including some limited in distribution to just the Sacramento-San Joaquin Delta itself. Many of these at-risk species occupy specific, disparate habitat niches, so it is important to not focus on only small sets of ecological processes or habitat types, which may end up benefiting only a narrow subset of the at-risk species which rely upon the Sacramento-San Joaquin Delta. Thus, a focus on multiple ecological processes and habitat types, as well as implementation of the other priority attributes in a given restoration project (or within a larger restoration program), is important to promote the re-establishment of the diverse suite of habitat conditions needed to support the broad assemblage of native Sacramento-San Joaquin Delta flora and fauna.

Table 1 includes 35 plants, seven of which have a federal special-status designation and eight that have a state special-status listing. Additionally, all of these plant species have a California Rare Plant Ranking (CRPR) of 1B or 2B, meaning that they are considered rare, threatened, or endangered within California by the California Native Plant Society. Twenty-eight of these plant species are endemic to the California floristic province, indicating the uniqueness and biodiversity contribution that the region provides.

Tables 2 through 7 include 11 invertebrates, 3 amphibians, 4 reptiles, 47 birds, 9 mammals, and 12 fishes. Twenty-five of these fish and wildlife species are listed as threatened or endangered under the federal Endangered Species Act. Fifteen bird species are listed as U.S. Fish and Wildlife Service bird of conservation concern, and 62 have a special status under state regulations (e.g., they are threatened, endangered, candidate, species of special concern, or fully protected). Twenty-eight of these fish and wildlife species are endemic to California.

Figure 1 shows a map of the subregions within the Sacramento-San Joaquin Delta as reported in the table column titled “Regions of the Delta with Documented Occurrence.” These include the Cache Slough-Yolo Bypass Complex, North Delta, East Delta, South Delta, West Delta, and Suisun Marsh. Figure 2 shows a map of the California Floristic Province.

Table 1. Special-Status Plant Species Referenced in Recovery and Conservation Planning Documents for the Delta

Common Name Scientific Name	Federal Listing Status[a]	State Listing Status[b]	CRPR Listing Status[c]	Habitat	Region(s) of the Delta with Documented Occurrence	Endemic to California Floristic Province	Flowering Period	Sources
Ferris' milk-vetch *Astragalus tener* var. *ferrisiae*	–	–	1B.1	Vernally mesic meadows and mildly alkaline flats in valley and foothill grassland, usually on dry, heavy clay or adobe soil; 0- to 2,500-foot elevation	Cache Slough-Yolo Complex	Yes	April–May	CALFED 2002
Alkali milk-vetch *Astragalus tener* var. *tener*	–	–	1B.2	Alkaline vernal pools and playas, and valley and foothill grassland with alkaline adobe clay soils; 3- to 2,000-foot elevation	Cache Slough-Yolo Complex, Eastern Delta, South Delta, Suisun Marsh, West Delta	Yes	March–June	DWR 2013; SFEI-ASC 2014; Reclamation et al. 2013; CALFED 2002
Heartscale *Atriplex cordulata*	–	–	1B.2	Sandy, saline, or alkaline flats or scalds, in chenopod scrub, meadows, and valley and foothill grassland (3- to 490-foot elevation)	Cache Slough-Yolo Complex, East Delta, Suisun Marsh, West Delta	Yes	April–October	DWR 2013; SFEI-ASC 2014; Reclamation et al. 2013; CALFED 2002
Brittlescale *Atriplex depressa*	–	–	1B.2	Alkaline clay soils in chenopod scrub, meadows and seeps, playas, valley and foothill grassland, or vernal pools; 3- to 1,050-foot elevation	Cache Slough-Yolo Complex, Suisun Marsh, West Delta	Yes	May–October	DWR 2013; SFEI-ASC 2014; Reclamation et al. 2013; CALFED 2002
Big tarplant *Blepharizonia plumosa*	–	–	1B.1	Valley and foothill grassland; 100- to 1,600-foot elevation	East Delta, South Delta, West Delta	Yes	July–October	CALFED 2002

Table 1. Special-Status Plant Species Referenced in Recovery and Conservation Planning Documents for the Delta (contd.)

Common Name Scientific Name	Federal Listing Status[a]	State Listing Status[b]	CRPR Listing Status[c]	Habitat	Region(s) of the Delta with Documented Occurrence	Endemic to California Floristic Province	Flowering Period	Sources
Bristly sedge *Carex comosa*	–	–	2B.1	Coastal prairie, marshes and swamps, valley and foothill grassland, on lake margins, and wet places; 0- to 2,100-foot elevation	North Delta, South Delta, West Delta	No	May–September	CALFED 2002
Congdon's tarplant *Centromadia parryi* ssp. *congdonii*	–	–	1B.2	Alkaline, often heavy clay soils in mesic areas within grassland communities with ruderal and native alkali-tolerant plants; 0- to 600-foot elevation	Suisun Marsh, West Delta	Yes	June–November	CALFED 2002
Hispid salty bird's-beak *Chloropyron molle* ssp. *hispidum*	–	–	1B.1	Mesic alkaline soils in meadows and seeps, playas, and valley and foothill grassland; 3- to 500-foot elevation	No documented extant CNDDB occurrences within Delta, but presumed present in Suisun Marsh	Yes	June–September	Reclamation et al. 2013; CALFED 2002
Soft salty bird's-beak *Chloropyron molle* ssp. *molle*	E	R	1B.2	Coastal salt marshes and swamps; 0- to 10-foot elevation	Suisun Marsh, West Delta	Yes	July–September	DWR 2013; Reclamation et al. 2013; CALFED 2002
Palmate-bracted salty bird's-beak *Chloropyron palmatum*	E	E	1B.1	Alkaline soils in chenopod scrub and valley and foothill grassland; 15- to 500-foot elevation	East Delta	Yes	June–August	CALFED 2002
Slough thistle *Cirsium crassicaule*	–	–	1B.1	Chenopod scrub habitat or along sloughs in marshes, and swamps and riparian scrub habitat; 0- to 300-foot elevation	South Delta	Yes	May–August	DWR 2017; DWR 2013; SFEI-ASC 2014; CALFED 2002

Table 1. Special-Status Plant Species Referenced in Recovery and Conservation Planning Documents for the Delta (contd.)

Common Name Scientific Name	Federal Listing Status[a]	State Listing Status[b]	CRPR Listing Status[c]	Habitat	Region(s) of the Delta with Documented Occurrence	Endemic to California Floristic Province	Flowering Period	Sources
Suisun thistle *Cirsium hydrophilum* var. *hydrophilum*	E	–	1B.1	Salt and brackish marshes; 0- to 3-foot elevation	Suisun Marsh	Yes	June–September	DWR 2013; SFEI-ASC 2014; USFWS 2013; Reclamation et al. 2013; CALFED 2002
Recurved larkspur *Delphinium recurvatum*	–	–	1B.2	Alkaline soils in cismontane woodland and valley and foothill grassland; 10- to 2,500-foot elevation	South Delta, West Delta	Yes	March–June	CALFED 2002
Dwarf downingia *Downingia pusilla*	–	–	2B.2	Vernally mesic sites in valley and foothill grassland and vernal pools; 3- to 1,500-foot elevation	Cache Slough-Yolo Complex, North Delta, Suisun Marsh	No	March–May	DWR 2013; SFEI-ASC 2014
Delta button-celery *Eryngium racemosum*	–	E	1B.1	Vernally mesic clay depressions in riparian scrub habitat; 10- to 100-foot elevation	South Delta, West Delta	Yes	June–September	DWR 2017; DWR 2013; SFEI-ASC 2014
Spiny-sepaled button-celery *Eryngium spinosepalum*	–	–	1B.2	Valley and foothill grassland and vernal pools; 250- to 3,000-foot elevation	West Delta	Yes	April–June	CALFED 2002
Contra Costa wallflower *Erysimum capitatum* ssp. *angustatum*	E	E	1B.1	Inland dunes, generally on stabilized dunes of sand and clay near Antioch along the San Joaquin River; 0- to 70-foot elevation	West Delta	Yes	March–July	SFEI-ASC 2014; CALFED 2002
Diamond-petaled California poppy *Eschscholzia rhombipetala*	–	–	1B.1	Alkaline and clay soils in valley and foothill grassland; 0- to 1,000-foot elevation	West Delta	Yes	March–April	CALFED 2002

Table 1. Special-Status Plant Species Referenced in Recovery and Conservation Planning Documents for the Delta (contd.)

Common Name Scientific Name	Federal Listing Status[a]	State Listing Status[b]	CRPR Listing Status[c]	Habitat	Region(s) of the Delta with Documented Occurrence	Endemic to California Floristic Province	Flowering Period	Sources
San Joaquin spearscale *Extriplex joaquinana*	–	–	1B.2	Alkaline soils in chenopod scrub, meadows and seeps, playas, and valley and foothill grassland; 3- to 2,750-foot elevation	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	Yes	April–October	DWR 2013; Robinson et al. 2014; CALFED 2002
Bogg's Lake hedge-hyssop *Gratiola heterosepala*	–	E	1B.2	Lake margin marshes and swamps and vernal pools in clay soils; 30- to 7,800-foot elevation	West Delta	No	April–August	DWR 2013; Robinson et al. 2014; CALFED 2002
Rose-mallow *Hibiscus lasiocarpos* var. *occidentalis*	–	–	1B.2	Freshwater marshes and swamps; generally found on wetted riverbanks and low peat islands in sloughs; 0- to 100-foot elevation	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, West Delta	Yes	June–September	CALFED 2002
Carquinez goldenbush *Isocoma arguta*	–	–	1B.1	Grows in alkaline soils on flats and low hills in valley and foothill grassland; often occurs on low benches near drainages and on mounds in swale areas	Cache Slough-Yolo Complex, Suisun Marsh	Yes	August–December	DWR 2013; SFEI-ASC 2014; CALFED 2002
Contra Costa goldfields *Lasthenia conjugens*	E	–	1B.1	Grows in vernal pools, swales, and other depressions in open grassland and woodland communities, often in alkaline soils	Suisun Marsh, West Delta	Yes	March–June	CALFED 2002

Table 1. Special-Status Plant Species Referenced in Recovery and Conservation Planning Documents for the Delta (contd.)

Common Name Scientific Name	Federal Listing Status[a]	State Listing Status[b]	CRPR Listing Status[c]	Habitat	Region(s) of the Delta with Documented Occurrence	Endemic to California Floristic Province	Flowering Period	Sources
Delta tule pea *Lathyrus jepsonii* var. *jepsonii*	–	–	1B.2	Freshwater and brackish marshes at sea level	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	Yes	May–September	DWR 2013; SFEI-ASC 2014; USFWS 2013; Reclamation et al. 2013; CALFED 2002
Legenere *Legenere limosa*	–	–	1B.1	Bottoms of vernal pools and other wet depressions in grassland communities	Cache Slough-Yolo Complex, North Delta, Suisun Marsh	Yes	April–June	DWR 2013; SFEI-ASC 2014; CALFED 2002
Heckard's peppergrass *Lepidium latipes* var. *heckardii*	–	–	1B.2	Alkaline flats and in alkaline grasslands along the edges of vernal pools	Cache Slough-Yolo Complex, North Delta	Yes	March–May	DWR 2013; SFEI-ASC 2014; CALFED 2002
Mason's lilaeopsis *Lilaeopsis masonii*	–	R	1B.1	Freshwater and brackish marshes, riparian scrub, generally found in tidal zones, on depositional soils; 0- to 30-foot elevation	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	Yes	April–November	DWR 2013; SFEI-ASC 2014; Reclamation et al. 2013; CALFED 2002
Delta mudwort *Limosella subulata*	–	–	2B.1	Riparian scrub, freshwater marsh, brackish marsh, generally on mud banks of the Delta in marshy or scrubby riparian; 0- to 10-foot elevation	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	May–August	DWR 2013; SFEI-ASC 2014; CALFED 2002
Colusa grass *Neostapfia colusana*	T	E	1B.1	Large vernal pools with adobe clay soils; 15- to 4,000-foot elevation	Cache Slough-Yolo Complex	Yes	May–August	CALFED 2002

Table 1. Special-Status Plant Species Referenced in Recovery and Conservation Planning Documents for the Delta (contd.)

Common Name Scientific Name	Federal Listing Status[a]	State Listing Status[b]	CRPR Listing Status[c]	Habitat	Region(s) of the Delta with Documented Occurrence	Endemic to California Floristic Province	Flowering Period	Sources
Antioch Dunes evening primrose *Oenothera deltoides* ssp. *howellii*	E	E	1B.1	Inland dunes, remnant river bluffs, and sand dunes east of Antioch, along river bluffs, and in loose sand; 0- to 100-foot in elevation	West Delta	Yes	March–September	SFEI-ASC 2014; CALFED 2002
Eel-grass pondweed *Potamogeton zosteriformis*	–	–	2B.2	Marshes and swamps; 0- to 6,000-foot elevation	West Delta	No	June–July	CALFED 2002
Sanford's arrowhead *Sagittaria sanfordii*	–	–	1B.2	Assorted shallow freshwater marshes and swamps; 0- to 2,000-foot elevation	Cache Slough-Yolo Complex, East Delta, North Delta	Yes	May–October	CALFED 2002
Marsh skullcap *Scutellaria galericulata*	–	–	2B.2	Lower montane coniferous forest, meadows and seeps, marshes and swamps, wet places; 0- to 7,000-foot elevation	East Delta, North Delta, South Delta, West Delta	No	June–September	CALFED 2002
Side-flowering skullcap *Scutellaria lateriflora*	–	–	2B.2	Marshes and swamps, meadows and seeps; 0- to 1,500-foot elevation	East Delta, North Delta	No	July–September	DWR 2013; SFEI-ASC 2014
Suisun Marsh aster *Symphyotrichum lentum*	–	–	1B.2	Marshes and swamps, often along sloughs; 0- to 10-foot elevation	Suisun Marsh	Yes	May–November	DWR 2013; SFEI-ASC 2014; Reclamation et al. 2013; CALFED 2002

Source: California Natural Diversity Database (CNDDB) 2018; California Native Plant Society (CNPS) 2018

Table 1. Special-Status Plant Species Referenced in Recovery and Conservation Planning Documents for the Delta (contd.)

Table Notes:

[a] **U.S. Fish and Wildlife Service Federal Listing Categories:**
T = Threatened
E = Endangered
– = No status.

[b] **California Department of Fish and Game State Listing Categories:**
R = Rare
E = Endangered
– = No status

[c] **California Rare Plant Rank:**
1A = Presumed extinct
1B = Plants rare, threatened, or endangered in California and elsewhere
2A = Plants presumed extirpated in California but common elsewhere
2B = Plants rare, threatened, or endangered in California, but more common elsewhere
3 = Plants for which more information is needed—a review list
4 = Plants of limited distribution—a watch list

CRPR Threat Rank:
0.1 = Seriously endangered in California (>80 percent of occurrences are threatened and/or in high degree and immediacy of threat)
0.2 = Fairly endangered in California (20–80 percent of occurrences are threatened)
0.3 = Not very endangered in California (<20 percent of occurrences are threatened, or no current threats are known)

Table 2. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Invertebrates

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Lange's metalmark butterfly	*Apodemia mormo langei*	E	–	Stabilized sand dunes along the San Joaquin River; endemic to the Antioch Dunes; host plant is nude buckwheat	West Delta	Yes	SFEI-ASC 2014; CALFED 2002
Conservancy fairy shrimp	*Branchinecta conservatio*	E	–	Vernal pools and swales	Cache Slough-Yolo Complex, Suisun Marsh	Yes	DWR 2013; SFEI-ASC 2014; CALFED 2002
Longhorn fairy shrimp	*Branchinecta longiantenna*	E	–	Small, shallow vernal pools and swales in alkali soils or rock outcrops	South Delta, West Delta	Yes	DWR 2013; SFEI-ASC 2014; CALFED 2002
Vernal pool fairy shrimp	*Branchinecta lynchi*	T	–	Vernal pools and other seasonal wetlands	Cache Slough-Yolo Complex, North Delta, South Delta, Suisun Marsh, West Delta	No	DWR 2013; SFEI-ASC 2014; CALFED 2002
Midvalley fairy shrimp	*Branchinecta mesovallensis*	–	–	Vernal pools	Cache Slough-Yolo Complex, West Delta	Yes	DWR 2013; CALFED 2002
Monarch butterfly	*Danaus plexippus*	–	–	Commonly overwinters in eucalyptus groves along the coast	Suisun Marsh[1]	No	CALFED 2002
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	T	–	Elderberry shrubs, typically in riparian habitats	North Delta, South Delta, Suisun Marsh	Yes	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; CALFED 2002
Delta green ground beetle	*Elaphrus viridis*	T	–	Found along the margins of vernal pools within 1.5 meters of the water	Cache Slough-Yolo Complex	Yes	CALFED 2002
Vernal pool tadpole shrimp	*Lepidurus packardi*	E	–	Vernal pools, swales, and other ephemeral wetlands	Cache Slough-Yolo Complex, North Delta, Suisun Marsh	Yes	DWR 2013; SFEI-ASC 2014; CALFED 2002

Table 2. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Invertebrates (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
California linderiella	*Linderiella occidentalis*	–	–	Vernal pools, swales, and other ephemeral wetlands	Cache Slough-Yolo Complex, North Delta, Suisun Marsh, West Delta	Yes	DWR 2013; SFEI-ASC 2014
Callippe silverspot butterfly	*Speyeria callippe callippe*	E	–	Found in native grassland and adjacent habitats, where females lay their eggs on the larval food plant, *Viola tricolor*	Suisun Marsh	Yes	CALFED 2002

Notes:

[1] Occurrence is based on observation of overwintering Monarchs in eucalyptus trees near the City of Fairfield in 1979. This spotting was considered unusual since this species in California typically overwinters in locations closer to the coast.

[a] **Federal Status:**

BCC = U.S. Fish and Wildlife Service bird of conservation concern (no legal status, but may warrant future listing under the federal Endangered Species Act [ESA] without additional conservation efforts)

E = Listed as endangered under the ESA

T = Listed as threatened under the ESA

– = No status.

[b] **State Status:**

SSC = California species of special concern

E = Listed as endangered under the California Endangered Species Act (CESA)

T = Listed as threatened under CESA

WL = California Department of Fish and Wildlife watch list (list of species formerly listed as SSC, under ESA or CESA, or as Fully Protected).

– = No status.

[c] Species occurrence is based on California Natural Diversity Database (CNDDB) 2018 records search for special-status species. For those species not tracked by CNDDB (e.g., nonlisted, potentially common species), the table presents regions of Delta with potentially suitable habitat.

Table 3. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Amphibians

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
California tiger salamander	*Ambystoma californiense*	T	T, WL	Winter breeding in vernal pools and seasonal wetlands with a minimum 10-week inundation period; in summer, aestivates in grassland habitat, primarily in rodent burrows	Cache Slough-Yolo Complex, East Delta, South Delta, Suisun Marsh, West Delta	Yes	DWR 2013; CDFW 2015; CALFED 2002
California red-legged frog	*Rana draytonii*	T	SSC	Foothill streams with dense shrubby or emergent riparian vegetation, minimum 11-20 weeks of water for larval development, and upland refugia for aestivation (dormancy)	South Delta, Suisun Marsh, West Delta	No	DWR 2013; SFEI-ASC 2014; CDFW 2015; CALFED 2002
Western spadefoot toad	*Spea hammondii*	–	SSC	In winter, breeds in vernal pools and seasonal wetlands with a minimum three-week inundation period; in summer, aestivates in grassland habitat, in soil crevices and rodent burrows	No documented extant CNDDB occurrences within Delta, but multiple observations close to South Delta, southwest of Tracy	No	CDFW 2015; CALFED 2002

Table 3. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Amphibians (contd.)

Notes:
[a] **Federal Status:**
BCC = U.S. Fish and Wildlife Service bird of conservation concern (no legal status, but may warrant future listing under the federal Endangered Species Act [ESA] without additional conservation efforts)
E = Listed as endangered under the ESA
T = Listed as threatened under the ESA
– = No status.
[b] **State Status:**
SSC = California species of special concern
E = Listed as endangered under the California Endangered Species Act (CESA)
T = Listed as threatened under CESA
WL = California Department of Fish and Wildlife watch list (list of species formerly listed as SSC, under ESA or CESA, or as Fully Protected).
– = No status.
[c] Species occurrence is based on California Natural Diversity Database (CNDDB) 2018 records search for special-status species. For those species not tracked by CNDDB (e.g., nonlisted, potentially common species), the table presents regions of Delta with potentially suitable habitat.

Table 4. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Reptiles

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Western pond turtle	*Actinemys marmorata*	–	SSC	Forages in ponds, marshes, slow-moving streams, sloughs, and irrigation ditches; nests in nearby uplands with low, sparse vegetation	East Delta; North Delta; South Delta; Suisun Marsh; West Delta	No	DWR 2013; SFEI-ASC 2014; CDFW 2015; CALFED 2002
Silvery legless lizard	*Anniella pulchra pulchra*	–	SSC	Associated with a variety of vegetation types on sandy soils with accessible moisture, primarily but not exclusively in semi-stabilized dunes	West Delta	Yes	CDFW 2015

Table 4. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Reptiles (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Coast horned lizard	*Phrynosoma blainvilli*	–	SSC	Variety of open habitats, including chaparral, oak savanna, and grassland; found primarily in areas with sandy, friable soils, scattered shrubs, and abundant ant colonies	No documented extant CNDDB occurrences within Delta, but multiple observations close to South Delta, west of Tracy	No	CDFW 2015
Giant garter snake	*Thamnophis gigas*	T	T	Forages in slow-moving streams, sloughs, ponds, marshes, inundated floodplains, rice fields, and irrigation and drainage canals; also requires upland refugia not subject to flooding during the snake's inactive season	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	Yes	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; CDFW 2015; USFWS 2017; CALFED 2002

Table Notes:

[a] **Federal Status:**
BCC = U.S. Fish and Wildlife Service bird of conservation concern (no legal status, but may warrant future listing under the federal Endangered Species Act [ESA] without additional conservation efforts)
E = Listed as endangered under the ESA
T = Listed as threatened under the ESA
– = No status.

[b] **State Status:**
SSC = California species of special concern
E = Listed as endangered under the California Endangered Species Act (CESA)
T = Listed as threatened under CESA
WL = California Department of Fish and Wildlife watch list (list of species formerly listed as SSC, under ESA or CESA, or as Fully Protected).
– = No status.

[c] Species occurrence is based on California Natural Diversity Database (CNDDB) 2018 records search for special-status species. For those species not tracked by CNDDB (e.g., nonlisted, potentially common species), the table presents regions of Delta with potentially suitable habitat.

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Tricolored blackbird	*Agelaius tricolor*	BCC	T	Nests colonially in large, dense stands of freshwater marsh, riparian scrub, and other shrubs and herbs; forages in grasslands and agricultural fields	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; DWR 2013; CALFED 2002
Grasshopper sparrow	*Ammodramus savannarum*	–	SSC (nesting)	Nests and forages in dense grasslands; favors a mix of native grasses, forbs, and scattered shrubs	Cache Slough-Yolo Complex, West Delta, South Delta	No	CDFW 2015; DiGaudio et al. 2017; CALFED 2002
Tule greater white-fronted goose	*Anser albifrons elgasi*	–	SSC (wintering)	Forages primarily in marshes dominated by tules, bulrushes, and cattails; forages to a lesser extent in rice and other grain fields	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta[1]	No	CDFW 2015
Golden eagle	*Aquila chrysaetos*	BCC	FP, WL	Nests and forages in a variety of open habitats, including grassland, shrubland, and cropland; most common in foothill habitats; rare foothill breeder; nests in cliffs, rock outcrops, and large trees	Cache Lough Complex, Yolo Bypass, West Delta, South Delta, Suisun Marsh	No	CDFW 2015; CALFED 2002

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Great egret	*Ardea alba*	–	CFGC (rookeries)	Nests colonially in tall trees; forages in freshwater and saline marshes, shallow open water, and occasionally cropland or low, open upland habitats, such as pastures	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; CALFED 2002
Great blue heron	*Ardea herodias*	–	CFGC (rookeries)	Nests colonially in tall trees; forages in freshwater and saline marshes, shallow open water, and occasionally cropland or low, open upland habitats, such as pastures	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; CALFED 2002
Short-eared owl	*Asio flammeus*	–	SSC (nesting)	Nests on the ground among herbaceous vegetation, such as grasses or cattails; forages in grasslands, agricultural fields, and marshes	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; CALFED 2002

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Burrowing owl	*Athene cunicularia hypugea*	BCC	SSC (nesting)	Nests and forages in grasslands, agricultural fields, and low scrub habitats, especially where ground squirrel burrows are present; occasionally inhabits artificial structures and small patches of disturbed habitat	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; DWR 2013; SFEI-ASC 2014; DiGaudio et al. 2017; CALFED 2002
Swainson's hawk	*Buteo swainsoni*	BCC	T (nesting)	Nests in isolated trees, open woodlands, and woodland margins; forages in grasslands and agricultural fields	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; DWR 2013; SFEI-ASC 2014; CALFED 2002
Dunlin	*Calidris alpina*		–	Mudflats, estuaries, marshes, flooded fields, sandy or gravelly beaches, and shores of lakes, ponds, and sloughs; nests in wet coastal tundra, grass or sedge tundra with pools and bogs	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Western sandpiper	*Calidris mauri*	–	–	Nonbreeding in mudflats, beaches, shores of lakes and ponds, shallow lagoons, artificial salt ponds, and flooded fields, various coastal habitats with flat or gently sloping muddy, sandy, or gravelly shores, less often inland at pond edges, rain pools, wet fields; nests on the ground in a shallow depression, lined with leaves, lichen, and other plant material	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a
Least sandpiper	*Calidris minutilla*	–	–	Nonbreeding in wet meadows, mudflats, flooded fields, shores of pools and lakes, narrow channels, edge of salt marsh, river sandbars, sometimes sandy beaches; nests in mossy or wet grassy tundra, in lush vegetation near pond, occasionally in drier areas with sparse vegetation or scattered bushes	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Western snowy plover	*Charadrius alexandrinus nivosus*	T, BCC	SSC	Nests and forages on sandy and gravelly beaches along the coast and the shores of inland alkali lakes	Cache Slough-Yolo Complex, West Delta, South Delta, Suisun Marsh	No	CDFW 2015; Dybala et al. 2017a; CALFED 2002
Mountain plover	*Charadrius montanus*	BCC	SSC (wintering)	Forages in short grasslands and plowed agricultural fields where vegetation is sparse and trees are absent	Cache Slough-Yolo Complex	No	CDFW 2015; CALFED 2002
Killdeer	*Charadrius vociferus*	–	–	Habitat includes various open areas such as fields, meadows, lawns, pastures, mudflats, and shores of lakes, ponds, rivers, and seacoasts; nests are on the ground in open dry or gravelly situations, sometimes in similar situations on roofs, driveways, etc.	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a; Strum et al. 2017
Northern harrier	*Circus cyaneus*	–	SSC (nesting)	Nests on the ground among herbaceous vegetation, such as grasses or cattails; forages in grasslands, agricultural fields, and marshes	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; DiGaudio et al. 2017; CALFED 2002

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	T, BCC	E	Nests in valley, foothill, and desert riparian forest with densely foliaged deciduous trees and shrubs, especially willows; other associated vegetation includes cottonwood trees, blackberry, nettle, and wild grape	Cache Slough-Yolo Complex, North Delta, South Delta	No	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; Dybala et al. 2017b; CALFED 2002
Yellow warbler	*Dendroica petechia*	–	SSC (nesting)	Nests and forages in early successional riparian habitats	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; Dybala et al. 2017b; CALFED 2002
White-tailed kite	*Elanus leucurus*	–	FP	Forages in ponds, marshes, slow-moving streams, sloughs, and irrigation ditches; nests in nearby uplands with low, sparse vegetation	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	DWR 2013; SFEI-ASC 2014; CDFW 2015; CALFED 2002
California horned lark	*Eremophila alpestris actia*	–	WL	Nests and forages in open habitats with sparse vegetation, including grasslands and fallow agricultural fields	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	DiGaudio et al. 2017

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
American peregrine falcon	*Falco peregrinus anatum*	BCC	FP	Forages in a wide variety of habitats, but is most common near water, where shorebirds and waterfowl are abundant	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; CALFED 2002
Saltmarsh common yellowthroat	*Geothlypis trichas sinuosa*	BCC	SSC	Primarily brackish marsh with dense and continuous wetland or riparian vegetation down to the water surface; to a lesser degree, also uses woody swamp and freshwater marsh; often found in rush, tall grass, and willow-dominated communities	Suisun Marsh, West Delta	Yes	CDFW 2015; USFWS 2013; Dybala et al. 2017b; Reclamation et al. 2013; CALFED 2002
Lesser sandhill crane	*Grus canadensis canadensis*	–	SSC (wintering)	Forages primarily in croplands with waste grain; also frequents grasslands and emergent wetlands	Yolo Bypass, North Delta, East Delta, South Delta, West Delta[2]	No	CDFW 2015
Greater sandhill crane	*Grus canadensis tabida*	–	T, FP	Forages primarily in croplands with waste grain; also frequents grasslands and emergent wetlands	Yolo Bypass, North Delta, East Delta, South Delta, West Delta[3]	No	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; CDFW 2015; CALFED 2002

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Bald eagle	*Haliaeetus leucocephalus leucocephalus*	BCC	E, FP	Forages primarily in large inland fish-bearing waters with adjacent large trees or snags, and occasionally in uplands with abundant rabbits, other small mammals, or carrion	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; CALFED 2002
Black-necked stilt	*Himantopus mexicanus*	–	–	Shallow salt or fresh water with soft muddy bottom; grassy marshes, wet savanna, mudflats, shallow ponds, flooded fields, borders of salt ponds and mangrove swamp; nests along shallow water of ponds, lakes, swamps, or lagoons	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a; Strum et al. 2017
Yellow-breasted chat	*Icteria virens*	–	SSC	Nests and forages in riparian thickets of willow and other brushy tangles near water and thick understory in riparian woodland	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, West Delta	No	DWR 2013; CDFW 2015; Dybala et al. 2017b; CALFED 2002
Least bittern	*Ixobrychus exilis*	BCC	SSC (nesting)	Nests and forages in cattail and bulrush marshes	Cache Slough-Yolo Complex, West Delta, East Delta, South Delta	No	CDFW 2015; CALFED 2002

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Loggerhead shrike	*Lanius ludovicianus*	BCC	SSC (nesting)	Nests in isolated shrubs and trees and woodland edges of open habitats; forages in grasslands, agricultural fields, and low scrub habitats	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; DiGaudio et al. 2017
California black rail	*Laterallus jamaicensis coturniculus*	BCC	T, FP	Nests and forages in saline, freshwater, or brackish emergent marshes with gently grading slopes and upland refugia with vegetative cover beyond the high-water line	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	DWR 2017a; DWR 2013; SFEI-ASC 2014; CDFW 2015; USFWS 2013; Reclamation et al. 2013; CALFED 2002
Long-billed dowitcher	*Limnodromus scolopaceus*	–		Nonbreeding in marshes, shores of ponds and lakes, mudflats and flooded fields, primarily in freshwater situations; nests on the ground in tundra and wet meadows, usually in marshes or grassy areas with scattered shrubs and trees near open fresh water	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Song sparrow "Modesto" population	*Melospiza melodia*	–	SSC	Nests and forages primarily in emergent marsh, riparian scrub, and early successional riparian forest habitats, and infrequently in mature riparian forest and sparsely vegetated ditches and levees	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, West Delta	Yes	Dybala et al. 2017b
Suisun song sparrow	*Melospiza melodia maxillaris*	BCC	SSC	Nests and forages in brackish water marshes dominated by cattails, tules, and pickleweed	Suisun Marsh, West Delta	Yes	DWR 2013; SFEI-ASC 2014; CDFW 2015; USFWS 2013; Reclamation et al. 2013; CALFED 2002
San Pablo song sparrow	*Melospiza melodia samuelis*	BCC	SSC	Coastal salt marshes dominated by pickleweed; nests in gumplant bordering slough channels	No documented extant CNDDB occurrences within Delta, but potential habitat in Suisun Marsh	Yes	CDFW 2015; USFWS 2013; CALFED 2002
Long-billed curlew	*Numenius americanus*	–		Nests in dry prairies and moist meadows, on ground usually in flat area with short grass, sometimes on more irregular terrain, often near rock or other conspicuous object	Potentially suitable habitat present throughout Delta, including Yolo Bypass and Suisun Marsh	No	Dybala et al. 2017a; CDFW 2015; CALFED 2002

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Whimbrel	*Numenius phaeopus*	–		Nests in sedge-dwarf shrub tundra, sedge-meadow, hummock-bog, moorlands, and heath-tundra, in depressions; often returns to same nesting area in successive years	Potentially suitable habitat present throughout Delta, including Yolo Bypass and Suisun Marsh	No	Dybala et al. 2017a
Osprey	*Pandion haliaetus*	–	WL	Forages exclusively in fish-bearing waters; nests in nearby trees or tall, constructed platforms	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; CALFED 2002
Double-crested cormorant	*Phalacrocorax auritus*	–	WL	Lakes, ponds, rivers, lagoons, swamps, coastal bays, marine islands, and seacoasts, usually within sight of land; nests on the ground or in trees in freshwater situations, and on coastal cliffs	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CALFED 2002

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Purple martin	*Progne subis*	–	SSC (nesting)	Nests in tree cavities, bridges, utility poles, lava tubes, and buildings; forages in foothill and low montane oak and riparian woodlands, and less frequently in coniferous forests and open or developed habitats	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015
Ridgway's rail	*Rallus longirostris obsoletus*	E	E, FP	Nests and forages in dense cordgrass and cattail marshes with vegetated refugia during the highest tides	Suisun Marsh	No	CDFW 2015; USFWS 2013; SFEI-ASC 2014; Reclamation et al. 2013; CALFED 2002
American avocet	*Recurvirostra americana*	–	–	Lowland marshes, mudflats, ponds, alkaline lakes, and estuaries; usually nests on open flats or areas with scattered tufts of grass on islands or along lakes (especially alkaline) and marshes	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a; Strum et al. 2017

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Bank swallow	*Riparia riparia*	–	T (nesting)	Nests in vertical banks or bluffs, typically adjacent to water, devoid of vegetation, and with friable, eroding soils; forages in a wide variety of habitats	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	CDFW 2015; DWR 2017a; DWR 2017c; Dybala et al. 2017b; CALFED 2002
California least tern	*Sternula antillarum browni*	E	E, FP	Prefers undisturbed nest sites on open or sparsely vegetated, sandy, or gravelly shores on beaches or near shallow-water estuaries where it often feeds; has reportedly also nested in landfills and on paved areas	Cache Slough-Yolo Complex, Suisun Marsh, West Delta	No	CDFW 2015; SFEI-ASC 2014; Reclamation et al. 2013; CALFED 2002
Lesser yellowlegs	*Tringa flavipes*	–	–	Nonbreeding in marshes, ponds, wet meadows, lakes, mudflats, and coastal salinas (coastal salt ponds or saline wetlands); nests in muskeg country, to edge of tundra, in marshes and bogs, clearings or burned-over sections of black spruce forest	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Greater yellowlegs	*Tringa melanoleuca*	–	–	Nonbreeding in marshes, ponds, lakes, stream margins, sand and gravel bars, lagoons, salinas (coastal salt ponds or saline wetlands), and coastal mudflats; nests in muskeg country or at other wetlands, on the ground in a slight depression in moss or dry peat, usually near water	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, Suisun Marsh, West Delta	No	Dybala et al. 2017a
Least Bell's vireo	*Vireo bellii pusillus*	E	E	Nests and roosts in low riparian thickets of willows and shrubs, usually near water but sometimes along dry, intermittent streams; other associated vegetation includes cottonwood trees, blackberry, mulefat, and mesquite (in desert)	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, West Delta	No	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; CDFW 2015; Dybala et al. 2017b; CALFED 2002
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	–	SSC (nesting)	Nests in freshwater emergent wetlands with dense vegetation and deep water, often along borders of lakes or ponds	Cache Slough-Yolo Complex, East Delta, North Delta, South Delta, West Delta	No	CDFW 2015

Table 5. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Birds (contd.)

Notes:

[1] Information based on the following reference: Shuford, W. D., and Gardali, T., editors. 2008. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento.

[2] Species occurrence distribution is based on BDCP Conservation Strategy (DWR 2013) analysis for greater sandhill crane, with the assumption that the two species share the same foraging and roosting habitats within the Delta.

[3] Species occurrence distribution is based on BDCP Conservation Strategy (DWR 2013) analysis.

[a] **Federal Status:**

BCC = U.S. Fish and Wildlife Service bird of conservation concern (no legal status, but may warrant future listing under the federal Endangered Species Act [ESA] without additional conservation efforts)

E = Listed as endangered under the ESA

T = Listed as threatened under the ESA

– = No status

[b] **State Status:**

SSC = California species of special concern

E = Listed as endangered under the California Endangered Species Act (CESA)

T = Listed as threatened under CESA

WL = California Department of Fish and Wildlife watch list (list of species formerly listed as SSC, under ESA or CESA, or as Fully Protected).

– = No status.

[c] Species occurrence is based on California Natural Diversity Database (CNDDB) 2018 records search for special-status species. For those species not tracked by CNDDB (e.g., nonlisted, potentially common species), the table presents regions of Delta with potentially suitable habitat.

Table 6. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Mammals

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Pallid bat	*Antrozous pallidus*	–	SSC	Deserts, grasslands, shrublands, woodlands, and forests; most common in open, dry habitats; roosts in rock crevices, oak hollows, bridges, and buildings	No documented extant CNDDB occurrences within Delta, but potential habitat in Delta, including West Delta and South Delta	No	CDFW 2015
Western mastiff bat	*Eumops perotis californicus*	–	SSC	Roosts in trees, rock crevices, and buildings in small colonies of fewer than 100 individuals; forages in a variety of grassland, shrub, and wooded habitats, including riparian and urban areas, although most commonly in open, arid lands	No documented extant CNDDB occurrences within Delta, but potential habitat in Delta, including West Delta and South Delta	No	CDFW 2015; CALFED 2002
Western red bat	*Lasiurus blossevillii*	–	SSC	Roosts primarily in tree foliage, occasionally shrubs, in small family groups rather than large colonies as other bats; prefers habitat edges and mosaics with trees that are protected from above and open below with open areas for foraging, including grasslands, shrublands, and open woodlands	North Delta, Suisun Marsh, West Delta	No	CDFW 2015
Riparian woodrat	*Neotoma fuscipes riparia*	E	SSC	Riparian forest, particularly dense willow thickets with an oak overstory	South Delta	Yes	DWR 2013; SFEI-ASC 2014; DWR 2017c

Table 6. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Mammals (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Salt marsh harvest mouse	*Reithrodontomys raviventris*	E	E, FP	Saline emergent marshes with low, dense cover of vegetation (especially pickleweed) and higher elevation refugia	Suisun Marsh, West Delta	Yes	DWR 2013; SFEI-ASC 2014; CDFW 2015; USFWS 2013; Reclamation et al. 2013; CALFED 2002
Suisun shrew	*Sorex ornatus sinuosus*	–	SSC	Marshes bordering Suisun Bay and northern San Pablo Bay	No documented extant CNDDB occurrences within Delta, but potential habitat in Suisun Marsh	Yes	DWR 2013; SFEI-ASC 2014; CDFW 2015; USFWS 2013; Reclamation et al. 2013; CALFED 2002
Riparian brush rabbit	*Sylvilagus bachmani riparius*	E	E	Dense thickets of brush associated with riparian habitats	East Delta, South Delta	Yes	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; CALFED 2002
American badger	*Taxidea taxus*	–	SSC	Drier open shrub, forest, and herbaceous habitats with friable soils	North Delta, South Delta, West Delta	No	CDFW 2015
San Joaquin kit fox	*Vulpes macrotis mutica*	E	T	Grasslands and oak savannas with friable soils; home range sizes of 600–1,300 acres	South Delta, West Delta	Yes	DWR 2013; SFEI-ASC 2014; CDFW 2015; CALFED 2002

Notes:
[a] **Federal Status:**
BCC = U.S. Fish and Wildlife Service bird of conservation concern (no legal status, but may warrant future listing under the federal Endangered Species Act [ESA] without additional conservation efforts)
E = Listed as endangered under the ESA
T = Listed as threatened under the ESA
– = No status.

[b] **State Status:**
SSC = California species of special concern
E = Listed as endangered under the California Endangered Species Act (CESA)
T = Listed as threatened under CESA
WL = California Department of Fish and Wildlife watch list (list of species formerly listed as SSC, under ESA or CESA, or as Fully Protected).
– = No status.
[c] Species occurrence is based on California Natural Diversity Database (CNDDB) 2018 records search for special-status species. For those species not tracked by CNDDB (e.g., nonlisted, potentially common species), the table presents regions of Delta with potentially suitable habitat.

Table 7. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Fish[1]

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Green sturgeon	*Acipenser medirostris*	T	SSC	Anadromous species, existing in the Sacramento River system, as well as in the Eel, Mad, Klamath, and Smith Rivers in the northwest portion of California	Potentially found throughout Delta waterways	No	DWR 2017a; SFEI-ASC 2014; DWR 2013; CDFW 2015; Reclamation et al. 2013; CALFED 2002
White sturgeon	*Acipenser transmontanus*	–	SSC	Anadromous species that spawns probably either over deep gravel riffles or in deep holes with swift currents and rock bottoms	Potentially found throughout Delta waterways	No	DWR 2013; SFEI-ASC 2014; CDFW 2015
Sacramento perch	*Archoplites interruptus*	–	CSC	Historically found in the sloughs, slow-moving rivers, and lakes of the Central Valley; prefer warm water; aquatic vegetation is essential for young (within native range only)	North Delta, West Delta	Yes[2]	CALFED 2002

Table 7. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Fish[1] (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Delta smelt	*Hypomesus transpacificus*	T	E	Spends most of its life in the Sacramento–San Joaquin Bay-Delta estuary; spawns in shallow, fresh or slightly brackish water upriver from the mixing zone	Potentially found throughout Delta waterways	Yes	DWR 2013; SFEI-ASC 2014; CDFW 2015; CNRA 2016; Reclamation et al. 2013; CALFED 2002
River lamprey	*Lampetra ayresii*		SSC	Adults need clean, gravelly riffles in permanent streams to spawn successfully; ammocoetes live in silty backwaters and eddies with muddy or sandy substrate into which they burrow	Potentially found throughout Delta waterways	No	DWR 2013; SFEI-ASC 2014; CDFW 2015
Pacific lamprey	*Lampetra tridentata*	–	–	Adults need clean, gravelly riffles in permanent streams to spawn successfully; ammocoetes live in silty backwaters and eddies with muddy or sandy substrate into which they burrow	Potentially found throughout Delta waterways	No	DWR 2013; SFEI-ASC 2014; CDFW 2015
Central Valley steelhead	*Oncorhynchus mykiss*	T	–	Anadromous species using riverine, estuarine, and saltwater habitat; migration potentially occurs year-round	Potentially found throughout Delta waterways	Yes	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; CDFW 2015; CNRA 2017; Reclamation et al. 2013; CALFED 2002

Table 7. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Fish[1] (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Central Valley Chinook salmon, fall-/late fall-run	*Oncorhynchus tshawytscha*	–	SSC	Anadromous species using riverine, estuarine, and saltwater habitat	Potentially found throughout Delta waterways	Yes	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; DWR 2017b; CDFW 2015; CNRA 2017; Reclamation et al. 2013; CALFED 2002
Central Valley spring-run Chinook salmon	*Oncorhynchus tshawytscha*	T	T	Anadromous species using riverine, estuarine, and saltwater habitat	Potentially found throughout Delta waterways	Yes	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2014; DWR 2017b; CDFW 2015; CNRA 2017; Reclamation et al. 2013; CALFED 2002
Sacramento River winter-run Chinook salmon	*Oncorhynchus tshawytscha*	E	E	Anadromous species using riverine, estuarine, and saltwater habitat	Potentially found throughout Delta waterways	Yes	DWR 2017a; DWR 2017c; DWR 2013; SFEI-ASC 2015; DWR 2017b; CDFW 2015; CNRA 2017; Reclamation et al. 2013; CALFED 2002
Sacramento splittail	*Pogonichthys macrolepidotus*	–	SSC	Splittail spawn in shallow water over flooded vegetated habitat with a detectable water flow; larvae and juveniles remain in riparian or annual vegetation along shallow edges on floodplains	Potentially found throughout Delta waterways	Yes	DWR 2013; SFEI-ASC 2014; CDFW 2015; CALFED 2002

Table 7. Special-Status Wildlife Species Referenced in Recovery and Conservation Planning Documents for the Delta: Fish[1] (contd.)

Common Name	Scientific Name	Federal Legal Status[a]	State Legal Status[b]	Habitat	Region(s) of the Delta with Documented Occurrence[c]	Endemic to California	Sources
Longfin smelt	*Spirinchus Thaleichthys*	–	T	The longfin smelt is an anadromous species that spawns in the Delta and rears in the brackish areas of the San Francisco Bay and Delta	Potentially found throughout Delta waterways	No	DWR 2013; SFEI-ASC 2014; CDFW 2015; Reclamation et al. 2013; CALFED 2002

Table Notes:

[1] CNDDB has insufficient information to determine precise distribution of fish species within the Delta and Suisun Marsh.

[2] Also introduced to other states including Arizona, Colorado, Nebraska, Nevada, Oregon, and Utah.

[a] **Federal Status:**

BCC = U.S. Fish and Wildlife Service bird of conservation concern (no legal status, but may warrant future listing under the federal Endangered Species Act [ESA] without additional conservation efforts)

E = Listed as endangered under the ESA

T = Listed as threatened under the ESA

– = No status.

[b] **State Status:**

SSC = California species of special concern

E = Listed as endangered under the California Endangered Species Act (CESA)

T = Listed as threatened under CESA

WL = California Department of Fish and Wildlife watch list (list of species formerly listed as SSC, under ESA or CESA, or as Fully Protected).

– = No status.

[c] Species occurrence is based on California Natural Diversity Database (CNDDB) 2018 records search for special-status species. For those species not tracked by CNDDB (e.g., nonlisted, potentially common species), the table presents regions of Delta with potentially suitable habitat.

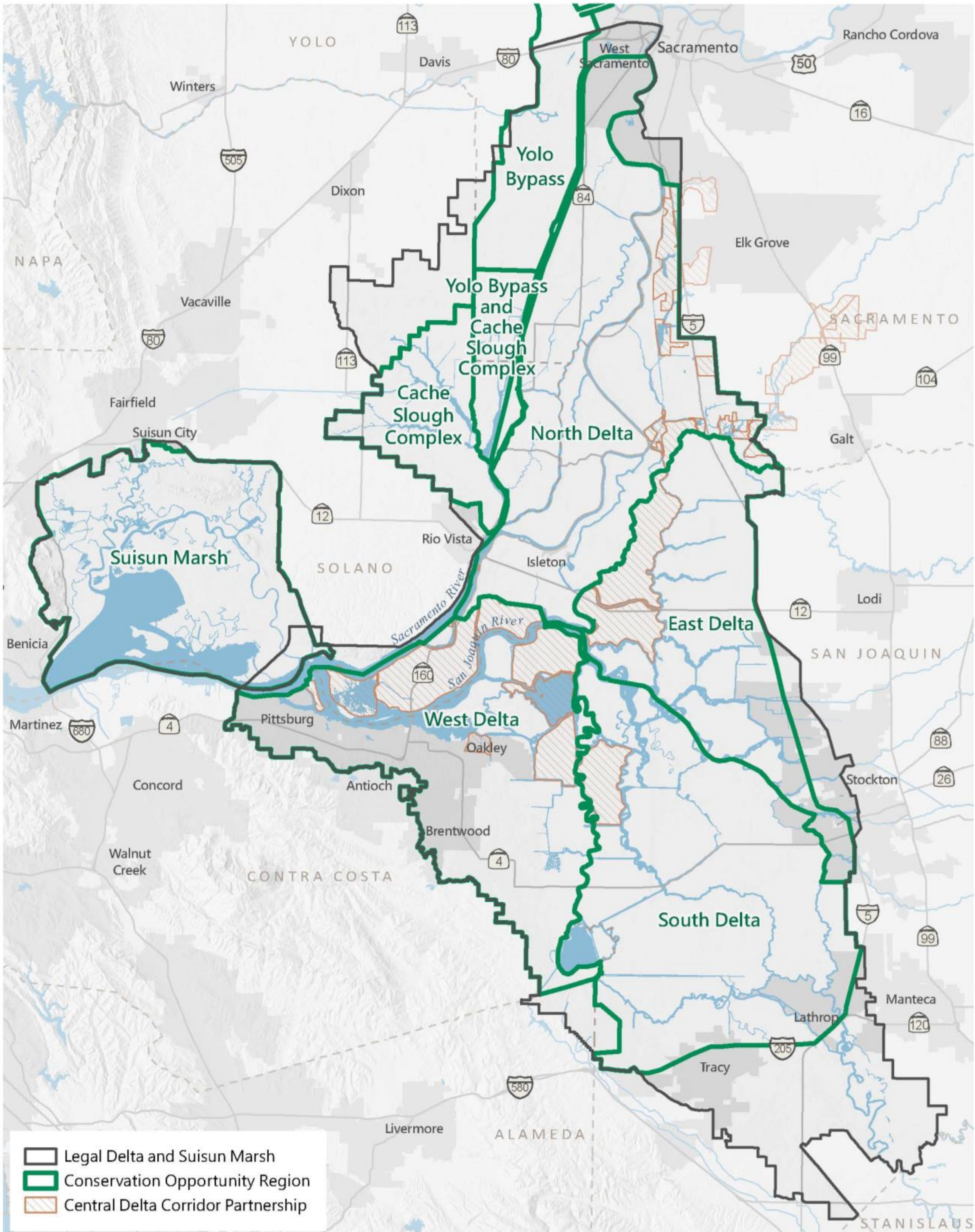

Figure 1. Regions of the Delta with Documented Special-Status Species Occurrence

Figure 1. Regions of the Delta with Documented Special-Status Species Occurrence (contd.)

This map illustrates Conservation Opportunity Regions and Central Delta Corridor Partnership areas in the Delta and Suisun Marsh. Conservation Opportunity Regions include the Suisun Marsh, Cache Slough Complex, Yolo Bypass, North Delta, East Delta, South Delta and West Delta. The Cache Slough and Yolo Bypass Conservation Opportunity Regions overlap at the boundary between Yolo and Solano Counties.

The Central Delta Corridor Partnership areas include Winter Island, Sherman Island, Twitchell Island, Dutch Slough, Webb Tract, and Holland Tract in the Western Delta Conservation Opportunity Region; Bacon Island in the South Delta Region; Bouldin Island and Staten Island in the East Delta Region; and a variety of smaller areas along the eastern boundary of the Delta in the North Delta Region, including McCormack Williamson Tract and the Stone Lakes National Wildlife Refuge.

Alternative formats of this map are available upon request.

Figure 2. California Floristic Province

This map illustrates the extent of the California Floristic Province along the West Coast of the United States, which ranges from southern Oregon to northwestern Mexico, and east to the Sierra Nevada mountains. The Delta and Suisun Marsh are fully within the California Floristic Province.

Alternative formats of this map are available upon request.

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Attachment C-4
Performance Measures

Appendix C
Attachment C-4.1
Proposed Amendment to Delta Plan Appendix E, Performance Measures for the Delta Plan Chapter 4: Protect, Restore, and Enhance the Delta Ecosystem

DRAFT

APPENDIX E. Performance Measures for the Delta Plan

Delta Plan Amendments

May 2020

For assistance interpreting the content of this document, please contact Delta Stewardship Council staff.

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Appendix E
Performance Measures for the Delta Plan

Performance Measure Types

Delta Plan performance measures have been placed into three general categories:

- Administrative performance measures describe decisions made by policy makers and managers to finalize plans or approve resources (funds, personnel, projects) for implementation of a program or group of related programs.
- Output (also known as "driver") performance measures evaluate the factors that may be influencing outcomes; including on-the-ground implementation of management actions, such as acres of habitat restored or acre-feet of water released, as well as natural phenomena outside of management control (such as a flood, earthquake, or ocean conditions).
- Outcome performance measures evaluate responses to management actions or natural outputs.

Core Output/Outcome Performance Measure Criteria

- Metrics define the unit(s) of measure and other characteristics for tracking aspects of performance over time.
- Baselines are standards or historical reference conditions for comparing with current conditions.
- Targets are the desired future conditions or trends.

Adaptive Management

Performance measures are an integral component of the Delta Plan Adaptive Management framework. Assessments of performance measures will inform the adaptive management of the Delta Plan. The Delta Reform Act requires the Council to review the Delta Plan at least once every five years.

The Five-Year Review of the Delta Plan ensures that the Delta Plan is reviewed periodically, and updated if the Council deems appropriate, to incorporate new information or to modify policies and recommendations to further achievement of the coequal goals. Five-year assessments of performance measures are based on evaluation of interim milestones set for each measure. Assessments of performance measures will inform the Five-Year Review findings and recommendations. The Five-Year Review process also sets a framework for conducting an evaluation of performance measures for their effectiveness.

Chapter 4: Protect, Restore, and Enhance the Delta Ecosystem

Note: The performance measures corresponding to other chapters of the Delta Plan are not part of the proposed amendment and are not included in this document.

The Delta Plan core strategies addressed in this appendix are:

- Core Strategy 4.1: Create More Natural Functional Flows
- Core Strategy 4.2: Restore Habitat
- Core Strategy 4.3: Protect Land for Restoration and Safeguard Against Land Loss
- Core Strategy 4.4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species
- Core Strategy 4.5: Improve Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement

Outcome Performance Measures

Core Strategy 4.1 Create More Natural Functional Flows

Performance Measure 4.2 Functional Flows (NO CHANGE)

Restoring to a healthier estuary using more natural functional flows—including in-Delta flows[1] and tributary-input flow—to support ecological floodplain processes (e.g., spring peak flows along the Sacramento River, and more gradual recession flows at the end of the wet season).

Metric

1. Area and duration of inundation in the Yolo Bypass, evaluated annually on a five-year rolling basis.
2. Frequency of two-year return interval peak flows, between November 1 to April 30, evaluated annually on a five-year rolling basis, at Bend Bridge on the Sacramento River.

[1] Please see Chapter 6 *Water Quality* performance measure on salinity in-Delta flows for X2.

3. Rate of change in the hydrograph on the receding limb as measured from spring high flows to summer low flows, evaluated annually on a five-year rolling basis, at Bend Bridge on the Sacramento River.[2]

4. 10-year rolling average slope of the Delta outflow-inflow ratio, disaggregated by seasonal, annual, and 10-year periods and evaluated annually; outflow-inflow ratio in dry and critically dry years, evaluated annually on a five-year rolling basis.

Baseline

1. Modeling, for the years 1997–2012, estimates that events with a 14-day duration inundated 45,100 acres in 33 percent of years; 19,700 acres in 50 percent of years; and 16,400 acres in 67 percent of years. Events with a duration of at least 21 days are estimated to have covered 36,300 acres in 33 percent of years; 15,800 acres in 50 percent of years; and 10,000 acres in 67 percent of years, between November 1 and May 30.[3]

2. Hydrograph data for the Bend Bridge gage station (USGS gage 11377100) indicate that the magnitude of flow for pre-Shasta Dam (1891–1943) and post-Shasta Dam (1960–2013) events, with 14-day duration, are similar at approximately 20,000 cubic feet per second (cfs).[4] However, the pre-Shasta Dam historical 1.5-year recurrence interval peak flow (approximately 75,000 cfs) even now occurs approximately every two years, and the pre-Shasta Dam 10-year recurrence interval flow (206,200 cfs) has been nearly halved (133,842 cfs).[5]

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[2] For this performance measure, the focal period is from April 1 to July 31, but the start of spring flows will differ depending on water-year type and water-management actions. The definition of spring high flows, or the start of spring recession, is defined as the third consecutive day of decreasing flow following the last peak flow between March 15 and June 1. Low flows are defined as the date when the daily recession rate average, over five days, is less than 3.5 percent per day.

[3] This baseline reflects the existing Fremont Weir configuration as of 2017. Department of Water Resources (DWR). 2015. Yolo Bypass Salmonid Habitat Restoration and Fish Passage Hydrodynamic Modeling Draft Report. April 21. Provided courtesy of DWR.

[4] DWR 2016, Central Valley Flood Protection Plan Conservation Strategy, Appendix H, Tables 3-1 and 4-1. Shasta Dam was completed in 1943. The dates here coincide with dates used in the Central Valley Flood Protection Plan, and are illustrative of the pre- and post-Shasta periods.

[5] M. Michalková, H. Piégay, G.M. Kondolf, and S.E. Greco. 2011. Lateral Erosion of the Sacramento River, California (1942–1999), and Responses of Channel and Floodplain Lake to Human Influences. Earth Surface Processes and Landforms. 36(2): pp. 257–272. Available at: https://doi.org/10.1002/esp.2106

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3. Long-term hydrograph data from the U.S. Geological Survey gage station at Bend Bridge (USGS 11377100).
4. Long-term ratio of Delta outflow to Delta inflow. The period before construction of the Central Valley Project, State Water Project, and select major dams (hydrograph between 1931–1954) had a Delta outflow-inflow ratio of 0.88. Post-completion of most components of the State Water Project (hydrograph between 1981–2015), the Delta outflow-inflow ratio was 0.75.[6]

Target

1. By 2030, allow for at least 17,000 acres of inundation for at least 14 days in two out of three years, and at least 21 days in one out of two years, between November 1 and March 15.[7]
2. By 2030, at least one peak flow greater than 75,000 cfs, lasting at least 48 hours in duration, every two years, at Bend Bridge on the Sacramento River.[8]
3. By 2030, daily decrease in flow will be less than 3.5 percent per day, as calculated by a five-day rolling average during the period of spring flow recession, in at least 1 out of 5 years, at Bend Bridge on the Sacramento River.[9]
4. By 2030, 10-year rolling average slope of Delta outflow-inflow ratio is greater than zero (i.e., positive),[10] and annual average Delta outflow-inflow ratio in dry as well as in critically dry years is greater than 0.5.[11]

Core Strategy 4.2: Restore Ecosystem Function

Performance Measure 4.15 Seasonal Inundation (NEW)

Restoring land-water connections to increase hydrologic connectivity and seasonal floodplain inundation.

Metric

Acres within the Sacramento-San Joaquin Delta and Suisun Marsh that are:

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[6] Delta Inflow and Net Delta Outflow Index estimates for the period of 1929–1955 can be retrieved from DWR: http://www.water.ca.gov/dayflow

[7] This performance measure may be refined to ensure consistency with the State Water Resources Control Board update of the Bay-Delta Water Quality Control Plan.

[8] This performance measure may be refined to ensure consistency with the State Water Resource Control Board update of the Bay-Delta Water Quality Control Plan.

[9] Target recession rate informed by research and analyses conducted for the Environmental Flows Tool (Alexander et al. 2014) and Stillwater Sciences (2007).

[10] Positive slope of the 10-year rolling average of Delta outflow-inflow ratio means an increasing portion of inflow water flowing out of the Delta over a given period of time.

[11] Following the State Water Resources Control Board's completion of updates to the Bay-Delta Water Quality Control Plan, this performance measure will be reevaluated for consistency with the Board's regulations.

1. Hydrologically connected to fluvial and tidally influenced waterways.
2. A nontidal floodplain[12] area that inundates[13] at least once every two years.

Metric will be evaluated annually.

Baseline

As of the year 2018:

1. An estimated 75,000 acres of land physically connected to the fluvial river and tidal system.
2. Approximately 15,000 acres of the connected land inundated at a two-year interval, calculated as a long-term average for 1985-2018.

Target

By 2050:

1. Additional 51,000 acres added to the 75,000-acre baseline that are physically connected to the fluvial river and tidal system, for a total of 126,000 acres.
2. At least an additional 19,000 acres of non-tidal floodplain area is inundated on a two-year recurrence interval, for a total of at least 34,000 acres.

Performance Measure 4.16 Acres of Natural Communities Restored (NEW)

Restoring large areas of natural communities to provide for habitat connectivity and crucial ecological processes, along with supporting viable populations of native species.

Metric

Acres of natural communities restored. This metric will be updated and evaluated every five years.

Baseline

Acres of natural communities from the 2007 Vegetation Classification and Mapping Program (VegCAMP) dataset by the California Department of Fish and Wildlife (CDFW), as designated below:

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[12] Area that is inundated on a two-year recurrence frequency and is connected via surface water to the fluvial river or tidal system.

[13] There is no depth threshold for the inundation analysis, as inundation is deemed to occur at any depth. While depth of inundation is important for ecological processes, the available data do not include depth measurements.

Ecosystem Type	Baseline Acres (2007 VegCAMP)
Seasonal Wetland Wet Meadow Nontidal Wetland	5,100
Willow Riparian Scrub/Shrub Valley Foothill Riparian Willow Thicket	14,200
Tidal Wetland	19,900
Stabilized Interior Dune Vegetation	20
Oak Woodland	0
Grassland	33,000
Vernal Pool Complex	5,100
Alkali Seasonal Wetland Complex	700

Target

Net increase of target acres of natural communities by 2050:

Ecosystem Type	Target Acres Net Increase (from Baseline Acres)	Total Area (Baseline Acres Plus Net Increase)
Seasonal Wetland Wet Meadow Nontidal Wetland	19,000	24,100
Willow Riparian Scrub/Shrub Valley Foothill Riparian Willow Thicket	16,300	30,500
Tidal Wetland	32,500	52,400
Stabilized Interior Dune Vegetation	640	660
Oak Woodland	13,000	13,000
Grassland	No net loss	33,000
Vernal Pool Complex	670	5,770
Alkali Seasonal Wetland Complex	230	930

Core Strategy 4.4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

Performance Measure 4.10 Terrestrial and Aquatic Invasive Species (NO CHANGE)

Prevention and reduction of key nonnative terrestrial and aquatic invasive species in the Delta and Suisun Marsh.

Metrics

To be evaluated annually:

1. Number of key new nonnative invasive species of fish, plants, and invertebrates establishing populations in the Delta (e.g., quagga and zebra mussels, *Hydrilla verticillata*, and others as they are identified).

2. Managing nonnative fish:

    i. Percentage of the total biomass of fish that are native fish species based on U.S. Fish and Wildlife Service (USFWS) beach seine surveys (and other relevant surveys).

    ii. Percentage of total relative abundance that are native species in the Delta and Suisun Marsh based on USFWS beach seine surveys (and other relevant surveys).

3. Managing invasive nonnative vegetation:

    i. Number of acres treated for invasive plants as defined by individual plans and projects (e.g., Central Valley Flood Protection Plan Conservation Strategy, *Arundo* control project, California Division of Boating and Waterways aquatic invasive species control programs).

    ii. Peak coverage, in acres, of invasive nonnative plant species (e.g., *Eichhornia crassipes*, *Ludwigia* spp., *Egeria densa*, *Arundo donax*, and *Phragmites australis*) in the Delta and Suisun Marsh.

Baseline

As of the year 2013[14]:

1. Species reported as established in the Delta prior to 2013 Delta Plan adoption will be used for baseline identification of new invasive species establishing post-2013.

2. Fish:

    i. Average percentage of total fish biomass that are native fish species based on USFWS beach seine surveys from the period of 1995-2015.

3. Vegetation:

    i. Number of acres treated set at zero as of 2013.

    ii. Peak coverage estimates, in acres, for nuisance nonnative aquatic plant species based on available hyperspectral and Landsat remote sensing surveys conducted in the Delta during the period of 2003–2016. *Arundo*

[14] Species reported as established in the Delta prior to 2013 Delta Plan adoption will be used for baseline identification of new invasive species established post-2013.

donax surveys conducted for the Delta Conservancy in 2015. Suisun Marsh vegetation surveys conducted between 1999–2013.

Target

To be achieved by 2030:

1. Zero new nonnative invasive species of fish, plants, and invertebrates established in the Delta.
2. Fish:[15]
   i. 20 percent increase in the biomass of the native inshore fish community, relative to total fish biomass.
   ii. 20 percent increase in the relative abundance of the native inshore fish community, compared to total relative abundance.
3. Vegetation:
   i. Acreage targets for treatment of invasive plants as defined by individual plans and projects:
      a. 680 acres within lower Sacramento.[16]
      b. 800 acres within lower San Joaquin.[17]
      c. 15 acres in the Cache Slough Complex (*Arundo* control project).
      d. 5,000 acres annually, for herbicide floating aquatic vegetation treatment in the Delta.[18]
      e. 2,500 acres during treatment seasons for herbicide submersed aquatic vegetation treatment in the Delta.[19]

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[15] Fish targets were calculated and derived from Mahardja, B., Farruggia, M.J., Schreier, B., and Sommer, T. (2017). *Evidence of a Shift in the Littoral Fish Community of the Sacramento-San Joaquin Delta*. PLOS ONE, 12(1), e0170683. Percentage increase in native fish biomass and in relative abundance reflects percentage decrease in nonnative fish species of the respective metric. Nonnative fish may prey upon native species, compete for food, take over habitat space, and alter food webs.
[16] See the 2016 Draft Central Valley Flood Protection Plan Conservation Strategy for more details: http://www.water.ca.gov/conservationstrategy/docs/cs_draft.pdf.
[17] See the 2016 Draft Central Valley Flood Protection Plan Conservation Strategy for more details: http://www.water.ca.gov/conservationstrategy/docs/cs_draft.pdf.
[18] See the California State Parks Division of Boating and Waterways' Floating Aquatic Vegetation (FAV) Control Programs: http://www.dbw.ca.gov/?page_id=28995.
[19] This reduction in invasive vegetation is based on efforts from large-scale projects that address impacts of invasive species. This includes but is not limited to: individual plans and projects that include treatment, California EcoRestore program, and project and nonproject levee vegetation management. A full list of efforts will be described in the datasheet.

ii. A 50 percent reduction in peak nonnative invasive plant species coverage (acres), including, but not limited to: *Eichhornia crassipes*, *Ludwigia* spp., *Egeria densa, Arundo donax*, *Rubus armeniacus*, *Lepidium latifolium*, and *Phragmites australis*.

Performance Measure 4.6 Doubling Goal for Central Valley Chinook Salmon Natural Production (REVISED)

Increase in Central Valley Chinook salmon population recovery with natural production to reach the state and federal doubling goal.

Metric

Annual average natural production of all Central Valley Chinook salmon runs and for individual run types on select rivers: fall, late-fall, spring, and winter. Census will be conducted annually for the general population in the Central Valley and select rivers.

Baseline

Set by the Central Valley Project Improvement Act (CVPIA), the baseline is the 1967–1991 Chinook salmon natural production annual average of 497,054 for all Central Valley runs, and for individual run types on select rivers, the baseline values are specified below.[20]

Target

The 15-year rolling annual average of natural production for all Central Valley Chinook salmon runs increases for the period of 2035-2065, and reaches 990,000 fish by 2065, for each run on select rivers, the target values are specified below.[21]

[20] The baseline values in the table do not add up to the baseline for all runs because not all tributaries are included. The Council will only track individual run types for the select rivers specified in the table.
[21] The targets in the table do not add up to the target for all runs because not all tributaries are included. The Council will only track individual run types for the select rivers specified in the table.

Central Valley Chinook Salmon Natural Production Baseline and Target Levels by Run Type and Selected Rivers

Baseline (1967–1991)		Target (2065)	
Sacramento River Watershed	San Joaquin River Watershed	Sacramento River Watershed	San Joaquin River Watershed
Sacramento River mainstem Fall: 115,369 Late-Fall: 33,941 Spring: 29,412 Winter: 54,316	Tuolumne River Fall: 18,949	Sacramento River mainstem Fall: 230,000 Late-Fall: 68,000 Spring: 59,000 Winter: 110,000	Tuolumne River Fall: 38,000
American River Fall: 80,874	Merced River Fall: 9,005	American River Fall: 160,000	Merced River Fall: 18,000
Feather River Fall: 86,028	Stanislaus River Fall: 10,868	Feather River Fall: 170,000	Stanislaus River Fall: 22,000
	Mokelumne River Fall: 4,680		Mokelumne River Fall: 9,300

Output Performance Measures

Core Strategy 4.2: Restore Ecosystem Function

Performance Measure 4.14 Increased Funding for Restoring Ecosystem Function (NEW)

Increased funding for projects that possess priority attributes to restore ecosystem functions and support a resilient, functioning Delta ecosystem.

Metric

Project funding of covered actions that file a certification of consistency under New ER Policy “A” (Disclose Contributions to Restoring Ecosystem Function). This metric excludes funding for projects that do not include protection, enhancement, or restoration of the Delta ecosystem. This metric will be reported annually.

Baseline

Set at zero as of the effective date of New ER Policy “A.”

Target

By 2030, 80 percent of total funding for covered action projects that file certifications of consistency with New ER Policy “A” is for projects with Ecosystem Restoration Tier 1 or 2 attributes.

Core Strategy 4.3: Protect Land for Restoration and Safeguard Against Land Loss

Performance Measure 4.12 Subsidence Reversal for Tidal Reconnection (NEW)

Subsidence reversal[22] activities are located at shallow subtidal elevations to prevent net loss of future opportunities to restore intertidal wetlands through tidal reconnection in the Delta and Suisun Marsh.

Metric

1. Acres of Delta and Suisun Marsh land with subsidence reversal activity located on islands with large areas at shallow subtidal elevations. This metric will be reported annually.
2. Average elevation accretion at each project site presented in centimeters per year. This metric will be reported every five years. Tracking will continue until a project is tidally reconnected.

Baseline

1. In 2019, zero acres of subsidence reversal on islands with large areas at shallow subtidal elevations.
2. Soils in the Delta are subsiding between 0 cm/year and 1.8 cm/year.

Target

1. By 2030, 3,500 acres in the Delta and 3,000 acres in Suisun Marsh with subsidence reversal activities on islands with at least 50 percent of the area or at least 1,235 acres at shallow subtidal elevations.
2. For each project, an average elevation accretion of at least 4 centimeters per year until the project is tidally reconnected.

[22] Subsidence reversal is a process that halts soil oxidation and accumulates new soil material in order to increase land elevations. Examples of subsidence reversal activities are rice cultivation, managed wetlands, and tidal marsh restoration.

Core Strategy 4.4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

Performance Measure 4.13 Barriers to Migratory Fish Passage (NEW)

Remediate fish passage at priority barriers and select large rim dams in the Sacramento–San Joaquin River watershed, and screen priority diversions along native, anadromous fish migration corridors within the Delta.[23]

Metric

Priority fish migration barriers and select large rim dams in the Sacramento–San Joaquin River watershed, and unscreened diversions along native, anadromous fish migration corridors in the Delta and Suisun Marsh. This metric will be evaluated annually.

Baseline

Number of fish passage barriers, large rim dams, and unscreened diversions listed in:

1. CDFW 2018 Priority Barriers.
2. Central Valley Flood Protection Program (CVFPP) 2016 Conservation Strategy (Appendix K).
3. Large rim dams in the Sacramento–San Joaquin River watershed identified in the National Marine Fisheries Service's Central Valley Recovery Plan for Central Valley Salmon and Steelhead (2014) with recovery actions.
4. Unscreened diversions along Delta native, anadromous migration corridors listed in the Passage Assessment Database (PAD) March 2018 version.

Target

1. By 2030, remediate all (100 percent) priority barriers identified in the 2018 CDFW priority barriers list. For subsequent updates, remediate 100 percent within 10 years of being included in the priority barrier list.
2. By 2030, remediate all (100 percent) of the priority fish migration barriers listed in CVFPP 2016 Conservation Strategy.
3. By 2050, remediate fish passage at all (100 percent) large rim dams in the Sacramento-San Joaquin River watershed.

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[23] *Remediate* in this context means to provide passage upstream and downstream to migratory fish by constructing, modifying, or removing a barrier.

- For rim dams, remediate means implementing a long-term fish passage program that may include capture, transport, and release of fish at different life stages.
- For unscreened diversions, remediate means to screen the diversion so that juvenile and adult fish are physically protected from entrainment.

4. By 2030, prioritize all (100 percent) unscreened diversions along native, anadromous fish migration corridors in the Delta, and by 2050 screen all (100 percent) priority diversions.

Administrative Performance Measures

Core Strategy 4.1: Create More Natural Functional Flows

- The State Water Resources Control Board adopts updates to the Bay-Delta Water Quality Control Plan, including updates to Delta outflow and Bay-Delta watershed tributary flow objectives, within one year of adoption of amendments to Chapter 4 of the Delta Plan (REVISED, corresponds to ER R1).

Core Strategy 4.2: Restore Habitat

- 100 percent of proposed actions that include ecosystem protection, enhancement, or restoration use the California Department of Water Resources (DWR) Good Neighbor Checklist to avoid or reduce conflicts with existing uses (NEW, corresponds to New ER Recommendation “B”).
- The U.S. Army Corps of Engineers (USACE) develops an agreed-upon variance process to exempt Delta levees from the USACE’s levee vegetation policy, where appropriate (NO CHANGE, corresponds to ER R4).

Core Strategy 4.3: Protect Land for Restoration and Safeguard Against Land Loss

- The San Francisco Bay Conservation and Development Commission (BCDC) updates and certifies components of the Suisun Marsh Protection Plan to address adaptation to sea level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act, and the Delta Plan (REVISED, corresponds to ER R5).
- The BCDC submits amendments of the Suisun Marsh Protection Plan to the Council for review, for consistency (NO CHANGE, corresponds to ER R5).
- The BCDC supports local governments and districts with jurisdiction in the Suisun Marsh in amending their components of the Suisun Marsh Local Protection Program to submit to the Council for review, for consistency (REVISED, corresponds to ER R5).
- The BCDC adopts the updated Suisun Marsh Protection Plan and certifies components of the Suisun Marsh Local Protection Program that are consistent with the Delta Plan (REVISED, corresponds to ER R5).

- The Sacramento–San Joaquin Delta Conservancy (Delta Conservancy) develops incentive programs for public and private landowners which encourage land management practices that stop subsidence on deeply subsided lands in the Delta and Suisun Marsh (NEW, corresponds to New ER Recommendation "C").
- State investments in ecosystem restoration in subsided areas, coordinated by DWR, CDFW, and the Delta Conservancy, are directed at projects that both reverse subsidence and restore intertidal marsh habitat (NEW, corresponds to New ER Recommendation "C").
- The California Legislature provides state agencies with funding to provide resources and support to resource conservation districts, and other local agencies and districts, to restore ecosystem function or improve agricultural land management practices that support native species (NEW, corresponds to New ER Recommendation "D").
- DWR, CDFW, the Delta Protection Commission, the Delta Conservancy, and other state agencies work with local resource conservation districts and other local agencies and districts to adaptively manage agricultural land management practices to improve habitat conditions for native bird and fish species (NEW, corresponds to New ER Recommendation "D").
- State and local agencies have developed management plans, for all publicly owned lands in the Delta or Suisun Marsh, which address subsidence and consider the feasibility of subsidence reversal (NEW, corresponds to New ER Recommendation "E").
- For all publicly owned lands in the Delta or Suisun Marsh, state and local agencies develop or update plans that identify land management goals, identify appropriate public or private uses for the land, and describe the operation and maintenance requirements needed to implement management goals. These activities address subsidence and consider the feasibility of subsidence reversal (NEW, corresponds to New ER Recommendation "E").

Core Strategy 4.4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

- The Delta Conservancy, Council's Delta Science Program, CDFW, California Department of Food and Agriculture, California Department of Parks and Recreation, Division of Boating and Waterways, and other state and federal agencies, develop and implement communication strategies, based on scientific expertise, to manage existing nonnative invasive species and for rapid response to address introductions of nonnative invasive species (REVISED, corresponds to ER R7).

- The Delta Conservancy, Council's Delta Science Program, CDFW, California Department of Food and Agriculture, California Department of Parks and Recreation, Division of Boating and Waterways, and other state and federal agencies, develop and implement funding strategies, based on scientific expertise, to manage existing nonnative invasive species and for rapid response to address introductions of nonnative invasive species (REVISED, corresponds to ER R7).
- CDFW prioritizes unscreened diversions in the Delta for remediation (NEW, corresponds to New ER Recommendation "H").
- Public agencies fund and implement projects that improve aquatic habitat conditions and reduce predation risk for juvenile salmon (NEW, corresponds to New ER Recommendation "I").
- CDFW and the USFWS ensure hatcheries develop, or continue to develop, periodically update, and implement scientifically sound Hatchery and Genetic Management Plans (HGMPs) (REVISED, corresponds to ER R8).
- CDFW, in cooperation with the USFWS and the National Marine Fisheries Service, coordinates researchers studying fish migration pathways and survival within the Delta waterways to improve synthesis of results across research efforts (REVISED, corresponds to ER R9).

Core Strategy 4.5: Improve Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement

- The Delta Plan Interagency Implementation Committee (DPIIC) develops strategies for acquisition and long-term ownership and management of lands necessary to achieve ecosystem restoration, consistent with the guidance in Appendix Q2 (NEW, corresponds to New ER Recommendation "F").
- DPIIC develops a funding strategy that identifies a portfolio of approaches to remove institutional barriers and fund Ecosystem Restoration Tier 1 or 2 actions within the Delta (NEW, corresponds to New ER Recommendation "F").
- DPIIC establishes program-level endangered species permitting mechanisms that increase efficiency for Ecosystem Restoration Tier 1 or 2 actions within the Delta and compatible ecosystem restoration projects within the Delta watershed (NEW, corresponds to New ER Recommendation "F").
- DPIIC coordinates with the Delta Science Program to align state, federal, and local resources for scientific support of restoration efforts, including adaptive

management, data tools, monitoring, synthesis, and communication (NEW, corresponds to New ER Recommendation “F”).

- DPIIC develops a landscape-scale strategy for recreational access to existing and future restoration sites, where appropriate, and while maintaining ecological value (NEW, corresponds to New ER Recommendation “F”).
- DPIIC coordinates alignment of state, local, and regional restoration strategies, plans, or programs in the Delta to be consistent with the priority attributes described in Appendix Q2 (NEW, corresponds to New ER Recommendation “G”).

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Appendix C
Attachment C-4.2
Non-substantive Revisions to Proposed Amendment to Delta Plan Appendix E, Performance Measures for the Delta Plan Chapter 4: Protect, Restore, and Enhance the Delta Ecosystem Since May 2020

Appendix C
Attachment C-4.2

Non-substantive Revisions Since May 2020 to Proposed Amendment to Delta Plan Appendix E. Performance Measures for the Delta Plan Chapter 4: Protect, Restore, and Enhance the Delta Ecosystem

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100 percent of proposed actions that include ecosystem protection, enhancement, or restoration use the ~~California Department of Water Resources (DWR)~~ Good Neighbor Checklist to avoid or reduce conflicts with existing uses (NEW, corresponds to New ER Recommendation “B”).

Page E-14

The BCDC supports local governments and districts with jurisdiction in the Suisun Marsh in amending their components of the Suisun Marsh Local Protection Program to submit to the Council for review**, for consistency with the Delta Plan**. (REVISED, Corresponds to ER R5)

Page E-15

The California Legislature provides state agencies with funding to provide resources and support to resource conservation districts**, reclamation districts,** and other local agencies and districts, to restore ecosystem function or improve agricultural land management practices that support native species. (NEW, corresponds to New ER Recommendation “D”).

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The California Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, should seek coordination among researchers studying **juvenile anadromous** fish migration pathways and survival **upstream of, and** within the Delta waterways to improve synthesis of results across research efforts **and application to adaptive management actions** (REVISED, corresponds to ER R9).

Attachment C
Attachment C-4.3
In-Line Edits of Proposed Amendment to Delta Plan Appendix E, Performance Measures for the Delta Plan Chapter 4: Protect, Restore, and Enhance the Delta Ecosystem

Appendix E:
Performance Measures for the Delta Plan

Redline of Proposed Draft Amendments Compared to Effective Version, Last Amended, April 26, 2018

Performance Measures for the Delta Plan[1]

Performance Measure Types

Delta Plan performance measures have been placed into three general classes:

- **Administrative** performance measures describe decisions made by policy makers and managers to finalize plans or approve resources (funds, personnel, projects) for implementation of a program or group of related programs.
- **Output** (also known as "driver") performance measures evaluate the factors that may be influencing outcomes**;** ~~and~~ **including**~~include~~ on-the-ground implementation of management actions, such as acres of habitat restored or acre-feet of water released, as well as natural phenomena outside of management control (such as a flood, earthquake, or ocean conditions).
- **Outcome** performance measures evaluate responses to management actions or natural outputs.

Core Output/Outcome Performance Measure Criteria

- **Metrics** define the unit(s) of measure and other characteristics for tracking aspects of performance over time.
- **Baselines** are standards or historical reference conditions for comparing with ~~the~~ current condition.
- **Targets** are the desired future conditions or trends.

Adaptive Management

Performance measures are an integral component of the Delta Plan Adaptive Management framework. Assessments of performance measures will inform the adaptive management of the Delta Plan. The Delta Reform Act requires the Council to review the Delta Plan at least once every five years.

The Five-Year Review of the Delta Plan ensures that the Delta Plan is reviewed periodically, and updated if the Council deems appropriate, to incorporate new information or to modify policies and recommendations to further achievement of the coequal goals. Five-year assessments of performance measures are based on evaluation of interim milestones set for each measure. Assessments of performance measures will inform the Five-Year Review findings and recommendations. The Five-Year Review process also sets a framework for conducting an evaluation of performance measures for their effectiveness.

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[1] The Council authorizes staff to make non-substantive alterations to metrics within these performance measures as follows: (1) such non-substantive alterations must be driven by the availability of new data sources or technologicalimprovements, and (2) such non-substantive alterations must be functionally equivalent to, or better than, the existing metrics or targets. The Council expects that any substantive alterations to metrics will be brought to the Council for review and approval.

Chapter 2: The Delta Plan

Administrative Performance Measures

- Establishment of the Delta Plan Interagency Implementation Committee by January 31, 2013.
- Completion of Report on Revisions to Delta Plan Performance Measures by December 31, 2014.
- The initial Delta Plan and all future revisions and amendments to the Delta Plan by the Council are consistent with an adaptive management approach and are informed by the best available science, where applicable.
- A minimum of every 5 years (beginning 5 years after adoption of the Delta Plan), the Delta Plan is reviewed by the Council and revised if deemed appropriate.
- Governance structure is reviewed and revised (if necessary) to ensure that there is adequate institutional capacity to interact, learn, and adapt in a manner that supports adaptive management.
- The Delta Science Program develops a Delta Science Plan including responding to Delta Independent Science Board review and comments by December 31, 2013.

Chapter 3: A More Reliable Water Supply for California

Core Strategy 3.1: Increase Water Conservation and Expand Local and Regional Supplies

Core Strategy 3.2: Improve Groundwater Management

Core Strategy 3.3: Improve Conveyance and Expand Storage Strategy

Core Strategy 3.4: Improved Water Management Information

Outcome Performance Measures

Core Strategy 3.1: Increase Water Conservation and Expand Local and Regional Supplies

- **PM 3.4.** Urban water suppliers that are within the Delta watershed, or those relying on water from the Delta watershed, demonstrate reliability during single and multiple dry years through their UWMPs. Single and multiple dry year projections should account for decreased availability of supplies from the Delta watershed. Reliability can be achieved through increased use of alternative supplies, demand management, or both. ~~(Strategy 3.1)~~
  - Metrics:
    - Percentage of urban water suppliers that are within the Delta watershed, or those relying on water from the Delta watershed, projecting reliability during a single dry year (i.e., lowest water supply available to the agency for a single year). This will be evaluated at least every five years as UWMPs are updated
    - Percentage of urban water suppliers that are within the Delta watershed, or those relying on water from the Delta watershed, projecting reliability for multiple dry years (i.e., lowest water supply available to the agency for three consecutive years). This will be evaluated at least every five years as UWMPs are updated.
  - Baseline:
    - Percentage of urban water suppliers that are within the Delta watershed, or those relying on water from the Delta watershed, projecting reliability during a single dry year in their 2015 UWMPs.
    - Percentage of urban water suppliers that are within the Delta watershed, or those relying on water from the Delta watershed, projecting reliability for multiple dry years in their 2015 UWMPs.
  - Target:
    - One-hundred percent of urban suppliers that are within the Delta

watershed, or those relying on water from the Delta watershed, project shortages no greater than 20 percent during single and multiple dry years by 2020—taking into account the reduced availability of water from the Delta watershed during dry years.

Core Strategy 3.3: Improve Conveyance and Expand Storage Strategy

- **PM 3.9.** A decrease in Delta exports during critically dry years, and an increase in Delta exports during wet years, with an overall average decrease in Delta exports.[2] ~~(Strategy 3.3)~~
  - Metrics:
    - Total water exported by the State Water Project and the Central Valley Project, during each critically dry year, through the Harvey O. Banks and C.W. Bill Jones Pumping Plants in the southern Delta. This will be evaluated following critically dry years.
    - Total water exported each wet year by the State Water Project and the Central Valley Project, through the Harvey O. Banks and C.W. Bill Jones Pumping Plants in the southern Delta. This will be evaluated following wet years.
    - Fifteen-year average total water exported annually (for all water year types) by the State Water Project and the Central Valley Project, through the Harvey O. Banks and C.W. Bill Jones Pumping Plants in the southern Delta. This will be evaluated at least every five years.
  - Baseline:
    - Median total water exported during critically dry years by the State Water Project and the Central Valley Project, through the Harvey O. Banks and C.W. Bill Jones Pumping Plants in the southern Delta, for the years 1975–2014.
    - Median total water exported during wet years by the State Water Project and the Central Valley Project, through the Harvey O. Banks and C.W. Bill Jones Pumping Plants in the southern Delta, for the years 1975–2014.
    - Average total water exported annually (for all water year types) by the State Water Project and the Central Valley Project, through the Harvey O. Banks and C.W. Bill Jones Pumping Plants in the southern Delta, for the years 2000–2014.
  - Target:
    - A statistically significant decrease in annual total exports during

[2] This performance measure will be re-evaluated for consistency with the State Water Resources Control Board's updates to the 2006 Bay-Delta Water Quality Control Plan. Phase I and II updates are currently expected to undergoreview and adoption in late 2017 or early 2018 (see: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta).

critically dry years as compared to historical deliveries for critically dry years in 1975–2014. This target is to be achieved by 2030.

- A statistically significant increase in total exports during wet years compared to historical deliveries for wet years in 1975–2014. This target is to be achieved by 2030.
- Fifteen-year average total exports during all year types decreases by 5 percent or more from the average historical deliveries for the years 2000–2014 (5.1 million acre-feet (MAF)). This target is to be achieved by 2030.

Output Performance Measures

Core Strategy 3.1: Increase Water Conservation and Expand Local and Regional Supplies

- **PM 3.1.** Urban water suppliers that are within the Delta watershed, or those relying on water from the Delta watershed, achieve their individual targets set through the Senate Bill (SB) X7-7 process or its successor legislation or regulatory targets. ~~(Strategy 3.1)~~
  - Metrics:
    - Gallons per capita per day of urban water use. This will be evaluated at least every five years as Urban Water Management Plans (UWMP) are updated.
    - Percentage change in urban per capita water use from SB X7-7 baseline years. This will be evaluated at least every five years as UWMPs are updated.
  - Baseline:
    - SB X7-7 baselines established in 2010/2015 UWMPs.
  - Target:
    - 2015 targets established in 2010/2015 UWMPs. Interim targets are set by individual suppliers, using one of four methods identified in SB X7-7, and are to be achieved by December 31, 2015, and reported in subsequent UWMPs.
    - 2020 targets established in 2010/2015 UWMPs. Targets are set by individual suppliers, using one of four methods identified in SB X7-7, and are to be achieved by December 31, 2020, and reported in subsequent UWMPs.
- **PM 3.2.** Urban water suppliers that are within the Delta watershed, or those relying on water from the Delta watershed, demonstrate sustained progress towards achieving their individual projections for water recycling, storm water capture, and use of advanced water technologies in their UWMPs. ~~(Strategy 3.1)~~

- Metrics:
  - Percentage of urban water suppliers meeting their recycled water projections. This will be evaluated at least every five years as UWMPs are updated.
  - Percentage of urban water suppliers meeting their storm water-use projections. This will be evaluated at least every five years as UWMPs are updated.
  - Percentage of urban water suppliers meeting their desalination projections. This will be evaluated at least every five years as UWMPs are updated.
- Baseline:
  - Each five-year UWMP update includes projections of future water supply sources in five-year increments.
- Target:
  - Suppliers meet at least 75 percent of their projected beneficial use of recycled water, storm water, and desalinated groundwater or ocean water, established in their previous UWMP. Achievement of target to be met every five years as set by UWMP updates.

Administrative Performance Measures

Core Strategy 3.1: Increase Water Conservation and Expand Local and Regional Supplies

- Identify number of water suppliers that have undertaken covered actions that have (1) completed a current urban or agricultural water management plan that has been reviewed by the DWR for compliance with applicable legal requirements, (2) commenced implementation of identified measures which will reduce reliance on the Delta, and (3) starting in 2015, reported on the expected outcome for measurable reductions in reliance on the Delta and improvement in regional self-reliance as the reduction in the amount of water used, or the percentage of water used, from the Delta watershed.
- Identify number of urban and agricultural water suppliers that certify that they have adopted and are implementing supply planning, conservation, and efficiency measures required by State law by 2015, meeting the standards and deadlines established by code.
- DWR adopts and implements a requirement for SWP contracts and transfer agreements that requires implementation of State water efficiency, water management laws, goals and regulations including compliance with water code section 85021.
- SWRCB adopts a policy that requires evaluation of new water rights or a new or changed point of diversion, place of use, or purpose that result in a new or increased long-term average use of water from the Delta watershed for

consistency with reasonable and beneficial use and Water Code sections 85021, 85023, and 85031 and other provisions of California law.

- Identify percentage of urban and agricultural water suppliers that receive water from the Delta watershed that have incorporated an expanded Water Supply Reliability Element in their UWMP and AWMP by December 31, 2015.
- DWR has developed and published guidelines for the preparation of an expanded Water Supply Reliability Element by December 31, 2014.
- DWR and SWRCB have established an advisory group and identified impediments to achievement of statewide water conservation, recycled water and stormwater goals by 2014 and have evaluated and recommended update goals by 2018, including an assessment of how regions are achieving their proportional share of these goals.
- State grant and loan ranking criteria have been revised by December 31, 2013.
- State agencies report to DSC on an annual basis on their actions to demonstrate state leadership, to increase water efficiency, use recycled water, and incorporate stormwater runoff capture and low impact development strategies.
- **PM.3.6.** Meet the requirement of SB X7-7, the Water Conservation Act of 2009, which requires agricultural water suppliers to submit an Agricultural Water Management Plan (AWMP) to the State of California Department of Water Resources (DWR). ~~(Strategy 3.1)~~
    - Metrics:
        - Percentage of AWMPs submitted to DWR on time. This will be evaluated at least every five years as AWMPs are updated.
        - Percentage of AWMPs submitted to DWR that include a quantification of water- use efficiency. This will be evaluated at least every five years as AWMPs are updated.
    - Baseline:
        - Fourteen percent of the required AWMPs (8 of the estimated 56) were submitted to DWR on time for the 2012 cycle. Thirty-seven percent of required AWMPs (35 of the estimated 95) were submitted to DWR on time for the 2015 cycle.
        - Zero percent of AWMPs (0 of the estimated 56 required) submitted to DWR for the 2012 cycle included a quantification of water-use efficiency improvements.
    - Target:
        - By 2020, 100 percent of AWMPs are submitted to DWR on time.
        - By 2020, 100 percent of AWMPs submitted to DWR include a quantification of water-use efficiency.

Core Strategy 3.2: Improve Groundwater Management

- Completion by DWR of the update of Bulletin 118 information (using field data, CASGEM, and best available science) and identification of the state's groundwater basins which are in a critical condition of overdraft by December 31, 2014.
- Information in updated Bulletin 118 is included in the next (2018) California Water Plan Update and the 2020 Urban Water Management Plans and Agricultural Water Management Plans.
- Number of water suppliers in areas that receive water from the Delta watershed that have developed groundwater management plans that are consistent with the required and recommended components of groundwater management plans listed in DWR Bulletin 118-03 by 2014.
- Identify number of groundwater basins identified by DWR as being in a critical condition of overdraft that have groundwater management plans consistent with the required and recommended components of groundwater management plans listed in DWR Bulletin 118-03 by 2014.
- SWRCB report to DSC on proposed action to address groundwater basins in critical overdraft.
- Responsible State and local agencies complete the 2014 Sustainable Groundwater Management Act (SGMA) mandates. Upon completion of Groundwater Sustainability Plans (GSPs), this measure will be updated to track achievement of the measurable objectives and five-year interim milestones identified by local agencies in the plan. Groundwater levels and groundwater storage will be targeted specifically. ~~(Strategy 3.2)~~
    - Metric:
        - Completion of actions required by SGMA. This will be evaluated annually until GSPs are completed.
    - Baseline:
        - N/A
    - Target:
        - The actions required by SGMA have various target dates. One-hundred percent of actions required by SGMA are completed by their target dates.[3]

[3] Seventeen actions leading to adoption of GSPs have been identified. These actions are to be completed by the Department of Water Resources, the State Water Resources Control Board, and local agencies, with target dates ranging from January 31, 2015, to January 31, 2022. All medium and high-priority basins must be managed under aGSP by January 31, 2022. Medium and high-priority basins subject to critical conditions of overdraft must be managed under a GSP by January 31, 2020. On April 1, following GSP adoption and annually thereafter, local agencies must provide a report on progress towards sustainability to the Department of Water Resources. These reports may form the basis for a future groundwater performance measure.

Core Strategy 3.3: Improve Conveyance and Expand Storage

- DWR completes Surface Water Storages studies by December 31, 2012 with recommendations for projects to be implemented.
- DWR has completed a survey of past grant applicants to identify projects that may implemented within the next 5 to 10 years to expand existing surface and groundwater storage facilities, create new storage, improve Delta conveyance facilities, and improve opportunities for water transfers by December 31, 2012.
- California Water Commission holds hearings and provides recommendation on priority projects by December 31, 2013.
- DWR and SWRCB, in collaboration with the DSC, have established an advisory group and recommended measures to reduce procedural and administrative impediments to water transfers by December 31, 2016.

Core Strategy 3.4: Improved Water Management Information

- DWR and Bureau of Reclamation contracting processes have been implemented consistent with applicable policies.
- SWRCB has modified its supplemental water diversion and use or progress reports to require additional information on water efficiency, water supply projects, and net (consumptive) use.
- DWR has completed the development and initiated implementation of an integrated statewide system for water use reporting in coordination with other state agencies by 2014.
- DWR has modified the California Water Plan update to include specified categories of information to be tracked.
- Development of appropriate performance measures will be done by DSC in consultation with the agencies. These performance measures will be rolled into the California Water Plan Update.
- DWR has prepared an assessment of the State’s water infrastructure.

Chapter 4: Protect, Restore, and Enhance the Delta Ecosystem

Core Strategy 4.1: Create More Natural Functional Flows

Core Strategy 4.2: Restore **Ecosystem Function**~~Habitat~~

Core Strategy 4.3: **Protect Land for Restoration and Safeguard Against Land Loss**~~Improve Water Quality to Protect the Ecosystem~~

Core Strategy 4.4: **Protect Native Species and Reduce the Impact of**~~Prevent Introduction of and Manage~~ **Nonnative Invasive Species** ~~Impacts~~

Core Strategy 4.5: Improve **Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement**~~Hatcheries and Harvest Management~~

Outcome Performance Measures

Core Strategy 4.1: Create More Natural Functional Flows

- **PM 4.2.** Restoring to a healthier estuary using more natural functional flows—including in-Delta flows[4] and tributary-input flow—to support ecological floodplain processes (e.g., spring peak flows along the Sacramento River, and more gradual recession flows at the end of the wet season). ~~(Strategy 4.1)~~
  - Metrics:
    - Area and duration of inundation in the Yolo Bypass, evaluated annually on a five-year rolling basis.
    - Frequency of two-year return interval peak flows, between November 1 to April 30, evaluated annually on a five-year rolling basis, at Bend Bridge on the Sacramento River.

      Rate of change in the hydrograph on the receding limb as measured from spring high flows to summer low flows, evaluated annually on a five-year rolling basis, at Bend Bridge on the Sacramento River.[5]
    - 10-year rolling average slope of the Delta outflow-inflow ratio, disaggregated by seasonal, annual, and 10-year periods and evaluated annually; outflow-inflow ratio in dry and critically dry years, evaluated annually on a five-year rolling basis.

[4] Please see Chapter 6 *Water Quality* performance measure on salinity in-Delta flows for X2.

[5] For this performance measure, the focal period is from April 1 to July 31, but the start of spring flows will differ depending on water-year type and water-management actions. The definition of spring high flows, or the start of spring recession, is defined as the third consecutive day of decreasing flow following the last peak flow between March 15 and June 1. Low flows are defined as the date when the daily recession rate average, over five days, is lessthan 3.5 percent per day.

- Baseline:
  - Modeling, for the years 1997–2012, estimates that events with a 14-day duration inundated 45,100 acres in 33 percent of years; 19,700 acres in 50 percent of years; and 16,400 acres in 67 percent of years. Events with a duration of at least 21 days are estimated to have covered 36,300 acres in 33 percent of years; 15,800 acres in 50 percent of years; and 10,000 acres in 67 percent of years, between November 1 and May 30 (DWR 2015).[6]
  - Hydrograph data for the Bend Bridge gage station (USGS gage 11377100) indicate that the magnitude of flow for pre-Shasta Dam (1891–1943) and post- Shasta Dam (1960–2013) events, with 14-day duration, are similar (approximately 20,000 cubic feet per second, CFS).[7] However, the pre-Shasta Dam historical 1.5-year recurrence interval peak flow (approximately 75,000 CFS) even now occurs approximately every two years, and the pre-Shasta Dam 10-year recurrence interval flow (206,200 CFS) has been nearly halved (133,842 CFS).[8]
  - Long-term hydrograph data from the U.S. Geological Survey gage station at Bend Bridge (USGS 11377100).
  - Long-term ratio of Delta outflow to Delta inflow. The period before construction of the Central Valley Project, State Water Project, and select major dams (hydrograph between 1931 – 1954) had a Delta outflow-inflow ratio of 0.88. Post- completion of most components of the State Water Project (hydrograph between 1981–2015), the Delta outflow-inflow ratio was 0.75.[9]
- Target:
  - By 2030, allow for at least 17,000 acres of inundation for at least 14 days in two out of three years, and at least 21 days in one out of two years, between November 1 and March 15.[10]
  - By 2030, at least one peak flow greater than 75,000 CFS, lasting at least 48 hours in duration, every two years, at Bend Bridge on the Sacramento River.[11]
  - By 2030, daily decrease in flow will be less than 3.5 percent per

[6] This baseline reflects the existing Fremont Weir configuration as of 2017.
[7] DWR 2016, Central Valley Flood Protection Plan Conservation Strategy, Appendix H, Tables 3-1 and 4-1. ShastaDam was completed in 1943. The dates here coincide with dates used in the Central Valley Flood Protection Plan, and are illustrative of the pre- and post-Shasta periods.
[8] Michalkova et al. 2011, Constantine 2006, and Micheli et al. 2011.
[9] Delta Inflow and Net Delta Outflow Index estimates for the period of 1929–1955 can be retrieved from DWR:http://www.water.ca.gov/dayflow
[10] This performance measure may be refined to ensure consistency with the State Water Resources Control Boardupdate of the Bay-Delta Water Quality Control Plan.
[11] This performance measure may be refined to ensure consistency with the State Water Resource Control Boardupdate of the Bay-Delta Water Quality Control Plan.

day, as calculated by a five-day rolling average during the period of spring flow recession, in at least 1 out of 5 years, at Bend Bridge on the Sacramento River.[12]

- By 2030, 10-year rolling average slope of Delta outflow-inflow ratio is greater than zero (i.e., positive)[13], and annual average Delta outflow-inflow ratio in dry as well as in critically dry years is greater than 0.5.[14]

Core Strategy 4.2: Restore Ecosystem Function

- **PM. 4.15. Restoring land-water connections to increase hydrologic connectivity and seasonal floodplain inundation.**
  - **Metrics:**
    - **Acres within the Sacramento-San Joaquin Delta and Suisun Marsh that are:**
      - **Hydrologically connected to fluvial and tidally influenced waterways.**
      - **A nontidal floodplain[15] area that inundates[16] at least once every two years.**
    - **Metric will be evaluated annually.**
  - **Baseline:**
    - **As of the year 2018:**
      - **An estimated 75,000 acres of land physically connected to the fluvial river and tidal system.**
      - **Approximately 15,000 acres of the connected land inundated at a two-year interval, calculated as a long-term average for 1985-2018.**
  - **Target:**
    - **By 2050:**
      - **Additional 51,000 acres added to the 75,000-acre baseline that are physically connected to the fluvial river and tidal system, for a total of 126,000 acres.**

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[12] Target recession rate informed by research and analyses conducted for the Environmental Flows Tool (Alexanderet al. 2014) and Stillwater Sciences (2007).

[13] Positive slope of the 10-year rolling average of Delta outflow-inflow ratio means an increasing portion of inflowwater flowing out of the Delta over a given period of time.

[14] Following the State Water Resources Control Board's completion of updates to the Bay-Delta Water QualityControl Plan, this performance measure will be reevaluated for consistency with the Board's regulations.

[15] **Area that is inundated on a two-year recurrence frequency and is connected via surface water to the fluvial river or tidal system**

[16] **There is no depth threshold for the inundation analysis, as inundation is deemed to occur at any depth. While depth of inundation is important for ecological processes, the available data do not include depth measurements**

- **At least an additional 19,000 acres of nontidal floodplain area is inundated on a two-year recurrence interval, for a total of 34,000 acres.**

- **PM. 4.16. Restoring large areas of natural communities to provide for habitat connectivity and crucial ecological processes, along with supporting viable populations of native species.**
  - **Metric:**
    - **Acres of natural communities restored. This metric will be updated and evaluated every five years.**
  - **Baseline:**
    - **Acres of natural communities from the 2007 Vegetation Classification and Mapping Program (VegCAMP) dataset by the California Department Fish and Wildlife (CDFW), as designated below:**

Ecosystem Type	Baseline Acres (2007 VegCAMP)
Seasonal Wetland Wet Meadow Nontidal Wetland	5,100
Willow Riparian Scrub/Shrub Valley Foothill Riparian Willow Thicket	14,200
Tidal Wetland	19,900
Stabilized Interior Dune Vegetation	20
Oak Woodland	0
Grassland	33,000
Vernal Pool Complex	5,100
Alkali Seasonal Wetland Complex	700

  - **Target:**
    - **Net increase of target acres of natural communities by 2050:**

Ecosystem Type	Target Acres Net Increase (from Baseline Acres)	Total Area (Baseline Acres Plus Net Increase)
Seasonal Wetland Wet Meadow Nontidal Wetland	19,000	24,100
Willow Riparian Scrub/Shrub Valley Foothill Riparian Willow Thicket	16,300	30,500
Tidal Wetland	32,500	52,400
Stabilized Interior Dune Vegetation	640	660
Oak Woodland	13,000	13,000
Grassland	No net loss	33,000

Ecosystem Type	Target Acres Net Increase (from Baseline Acres)	Total Area (Baseline Acres Plus Net Increase)
Vernal Pool Complex	670	5,770
Alkali Seasonal Wetland Complex	230	930

Core Strategy 4.4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

- **PM 4.6. Increase in Central Valley Chinook salmon population recovery with natural production to reach the state and federal doubling goal.** ~~Progress toward achieving the State and federal "doubling goal" for wild Central Valley salmon relative to the period of 1967-1991 levels. Trends will be derived from long-term salmon monitoring surveys conducted by the U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, and others. (Strategy 4.2)~~
    - Metrics:
        - ~~Number of naturally spawned wild adult salmon by run type, annually censused for the general population in the Central Valley and selected rivers:~~
            - ~~Sacramento River:~~
                - ~~American River~~
                - ~~Feather River~~
                - ~~Sacramento River mainstem~~
            - ~~San Joaquin River:~~
                - ~~Tuolumne River~~
                - ~~Merced River~~
                - ~~Stanislaus River~~
                - ~~Mokelumne River~~
        - **Annual average natural production of all Central Valley Chinook salmon runs and for individual run types on select rivers: fall, late-fall, spring, and winter. Census will be conducted annually for the general population in the Central Valley and select rivers.**
    - Baseline:
        - ~~Salmon population numbers relative to average levels during the period of 1967- 1991.~~
        - **Set by the Central Valley Project Improvement Act (CVPIA), the baseline is the 1967–1991 Chinook salmon natural production annual average of 497,054 for all Central Valley runs, and for individual run types on select rivers, the**

baseline values are specified in the table below.[17]

- Target:
    - ~~As defined by the Central Valley Project Improvement Act "doubling goal" that "…natural production of anadromous fish in Central Valley Rivers and streams will be sustainable, on a long term basis, at levels not less than twice the average levels attained during the period of 1967-1991."~~
    - **The 15-year rolling annual average of natural production for all Central Valley Chinook salmon runs increases for the period of 2035–2065, and reaches 990,000 fish by 2065, and for each run on select rivers, the target values are specified below.**[18]

Table 1. Central Valley Chinook Salmon Natural Production Baseline and Target Levels by Run Type and Selected Rivers

Watershed	River	Baseline (1967-1991)	Target (2065)
Sacramento River	Mainstem	Fall: 115,369 Late-Fall: 33,941 Spring: 29,412 Winter: 54,316	Fall: 230,000 Late-Fall: 68,000 Spring: 59,000 Winter: 110,000
Sacramento River	American River	Fall: 80,874	Fall: 160,000
Sacramento River	Feather River	Fall: 86,028	Fall: 170,000
San Joaquin River	Mokelumne River	Fall: 4,680	Fall: 9,300
San Joaquin River	Stanislaus River	Fall: 10,868	Fall: 22,000
San Joaquin River	Tuolumne River	Fall: 18,949	Fall: 38,000
San Joaquin River	Merced River	Fall: 9,005	Fall: 18,000

- ~~Progress toward the documented occurrence in and use of protected and restored habitats and migratory corridors by native resident and migratory Delta fish and bird species. Trends in the number of native species in protected and restored habitats and corridors will be derived from monitoring surveys that are conducted as part of adaptive management strategies for the protection and restoration of these areas. (Strategy 4.2)~~

    ~~Metrics:~~

    - ~~Assess native fish:~~
        - ~~Relative abundance of native fish in and near restoration project sites.~~

[17] **The baseline values in the table do not add up to the baseline for all runs because not all tributaries are included. The Council will only track individual run types for the select rivers specified in the table.**

[18] **The targets in the table do not add up to the target for all runs because not all tributaries are included.The Council will only track individual run types for the select rivers specified in the table.**

- Assess native birds:
    - Counts of native birds, including waterfowl in the Delta.

Baseline:

- Fish relative abundance as of Delta Plan adoption, May 2013.
- Breeding waterfowl for 2010-2014:
    - Delta counts (5-year average): 7,414
    - Suisun Marsh counts (5-year average): 23,122

Target:

- Upward trend as measured by the metrics above.

- Progress toward; 1) increased habitat, connectivity, and functionality; and 2) more favorable spatial distribution of habitat types. (Strategy 4.2)

  Metrics:

    - Assess the function 'Provides habitat and connectivity for fish'.
        - Spatial-temporal variability of seasonal short-term and long-term flooding and tidal inundation.
        - Marsh to open water ratio.
        - Adjacency of marsh to open water by length and marsh patch size.
        - Ratio of looped to dendritic channels (by length and adjacent habitat type).
    - Assess the function 'Provides habitat and connectivity for marsh wildlife'.
        - Marsh area by patch size (patch size distribution).
        - Marsh area by nearest large (>100 ha) neighbor distance.
        - Marsh core area ratio.
        - Marsh fragmentation index.
    - Assess the function 'Provides habitat and connectivity for waterbirds'.
        - Wetted area by type in winter.
    - Assess the function 'Provides habitat and connectivity for riparian wildlife'.
        - Riparian habitat area by patch size.
        - Riparian habitat length by width class.
    - Assess the function 'Provides habitat and connectivity for marsh-terrestrial transition zone wildlife'.
        - Length of marsh-terrestrial transition zone by terrestrial habitat type.

Baseline:

Metric	Baseline ("Modern" Delta)
Spatial-temporal variability of seasonal short-term and long-term flooding and tidal inundation	Tidal Inundation • Dec – Feb: 3,303 ha • Mar – May: 3,303 ha • Jun – Aug: 3,303 ha • Sep –Nov: 3,303 ha Seasonal long-duration flooding • Dec – Feb: 0 ha • Mar – May: 0 ha • Jun – Aug: 0 ha • Sep – Nov: 0 ha Seasonal short-term flooding • Dec – Feb: 18,128 ha • Mar – May: 18,128 ha • Jun – Aug: 0 ha • Sep – Nov: 0 ha
Marsh to Open Water Ratio	Marsh: 4,296 ha Open water: 26,554 ha Marsh to Open Water Ratio: 0.16
Adjacency of marsh to open water by length and marsh patch size	Marsh Patch >100 ha: 31 km Marsh Patch 10 – 100 ha: 236 km
Ratio of looped to dendritic channels	Dendritic channels adjacent to marsh: 84 km Dendritic channels not adjacent to marsh: 255 km Looped Channels: 768 km Fluvial or Detached: 298 km
Marsh area by patch size	<=10 ha: 1,427 ha 10 – 100 ha: 1,757 ha 100 – 1,000 ha: 1,154 ha 1,000 – 10,000 ha: 0 ha >10,000 ha: 0 ha

Metric	Baseline ("Modern" Delta)
Marsh area by nearest neighbor distance	<=10 m: 1,161 ha 10 – 100 m: 143 ha 100 – 1,000 m: 87 ha 1,000 – 10,000 m: 630 ha >10,000 m: 2,317 ha
Marsh core area ratio	Core Habitat: 815 ha Edge Habitat: 3,522 ha Core to Edge Ratio: 0.23
Marsh fragmentation index	Areas of marsh core habitat within large marsh patch (>100 ha) or within small patches < 1km from large patch: 491 ha
Wetted area by type in winter	Ponds, Lakes, Channels and Flooded Islands: 26,530 ha Tidal Inundation: 3,303 ha Seasonal long-duration flooding: 0 ha Seasonal short-term flooding: 18,128 ha

Riparian habitat area by patch size	<=20 ha: 1,991 ha 20 – 80 ha: 1,364 ha 80 – 320 ha: 1,470 ha 320 – 1,280 ha: 2,066 ha >1,280 ha: 0 ha	Riparian habitat length by width class	0 – 100m: 626 km 100 – 500m: 87 km >500 m: 11 km
Length of marsh- terrestrial transition zone by terrestrial habitat type	Willow Riparian Scrub or Shrub: 370 km Valley Foothill Riparian: 116 km Oak Woodland and Oak Savannah: 0 km Alkali Seasonal Wetland Complex: 19 km Wet Meadow and Seasonal Wetland: 30 km	Stabilized Interior Dune Vegetation: 0 km Grassland: 103 km Willow Thicket: 59 km Vernal Pool Complex: 4 km	

Target:

- Increasing extent of flooding by different inundation types throughout the year, including seasonal shallow short-term flooding, seasonal deeper long-duration flooding, and tidal inundation.
- Increasing proportion of marsh to open water habitat.
- Increasing proportion and extent of marsh-open water edge that occurs along large marsh patches (>100 ha). Decreasing proportion of marsh-open water edge that occurs along small marsh patches.
- Decreasing proportion of looped to dendritic channels.
- Increasing extent and proportion of marsh habitat that are in large size classes (>100 ha).
- Decreasing proportion of marsh that occurs in small size classes.
- Increasing proportion of marsh habitat that occurs in close proximity to a large marsh patch (>100 ha).
- Increasing proportion and extent of marsh habitat that occurs in "core" habitat (at least 50 m from outside edge of marsh).
- Increasing proportion and extent of marsh habitat that occurs either in core habitat of large marsh patches or in smaller patches less than 1 km from nearest large patch.
- Increased extent of different types of inundation for types wintering waterfowl.
- Increasing proportion and extent of riparian habitat that occur in larger patches. Decreasing proportion of riparian habitat that occurs in smaller patches.
- Increasing proportion and extent of riparian habitat length that occurs in wider width size classes. Decreasing proportion of

~~riparian habitat length that occurs in narrow width size classes.~~

- ~~Increasing length of marsh-terrestrial transition zone.~~

- **PM 4.10.** Prevention and reduction of key nonnative terrestrial and aquatic invasive species in the Delta and Suisun Marsh. ~~(Strategy 4.4)~~
  - Metrics:
    Metrics are to be evaluated annually:
    - Number of key new nonnative invasive species of fish, plants, and invertebrates establishing populations in the Delta (e.g., Quagga and Zebra mussels, *Hydrilla verticillata*, and others as they are identified).
    - Managing nonnative fish:
      - Percentage of the total biomass of fish that are native fish species based on USFWS beach seine surveys (and other relevant surveys).
      - Percentage of total relative abundance that are native species in the Delta and Suisun Marsh based on USFWS beach seine surveys (and other relevant surveys).
    - Managing invasive nonnative vegetation:
      - Number of acres treated for invasive plants as defined by individual plans and projects (e.g., Central Valley Flood Protection Plan Conservation Strategy, Arundo control project, California Division of Boating and Waterways (DBW) aquatic invasive species control programs, etc.).
      - Peak coverage, in acres, of invasive nonnative plant species (e.g., *Eichhornia crassipes, Ludwigia spp., Egeria densa, Arundo donax, and Phragmites australis*) in the Delta and Suisun Marsh.
  - Baseline:
    - Species reported as established in the Delta prior to 2013 Delta Plan adoption will be used for baseline identification of new invasive species established post-2013.
    - Fish:
      - Average percentage of total fish biomass that are native fish species based on USFWS beach seine surveys from the period of 1995-2015.
    - Vegetation:
      - Number of acres treated set at zero as of 2013.
    - Peak coverage estimates, in acres, for nuisance nonnative aquatic plant species based on available hyperspectral and Landsat remote sensing surveys conducted in the Delta during the period of 2003–2016. *Arundo donax* surveys conducted for the Delta

Conservancy in 2015. Suisun Marsh vegetation surveys conducted between1999–2013.

- Target:

  To be achieved by 2030:

  - Zero new nonnative invasive species of fish, plants, and invertebrates established in the Delta.
  - Fish:[19]~~[15]~~
    - 20 percent increase in the biomass of the native inshore fish community, relative to total fish biomass.
    - 20 percent increase in the relative abundance of the native inshore fish community, compared to total relative abundance.
  - Vegetation:
    - Acreage targets for treatment of invasive plants as defined by individual plans and projects:
      - 680 acres within lower Sacramento.[20]~~[16]~~
      - 800 acres within lower San Joaquin.[21]~~[17]~~
      - 15 acres in the Cache Slough Complex (Arundo control project).
      - 5,000 acres annually, for herbicide floating aquatic vegetation treatment in the Delta.[22]~~[18]~~
      - 2,500 acres during treatment seasons for herbicide submersed aquatic vegetation treatment in the Delta.[23]~~[19]~~
  - A 50 percent reduction in peak nonnative invasive plant species coverage (acres), including, but not limited to: *Eichhornia crassipes*, *Ludwigia spp.*, *Egeria densa*, *Arundo donax*, *Rubus armeniacus*, *Lepidium latifolium*, and *Phragmites australis.*

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[19]~~[15]~~ Fish targets were calculated and derived from Mahardja, B., Farruggia, M.J., Schreier, B., and Sommer, T. (2017).*Evidence of a Shift in the Littoral Fish Community of the Sacramento-San Joaquin Delta*. PLOS ONE, 12(1), e0170683. Percentage increase in native fish biomass and in relative abundance reflects percentage decrease in nonnative fish species of the respective metric. Nonnative fish may prey upon native species, compete for food, takeover habitat space, and alter food webs

[20]~~[16]~~ See the 2016 Draft Central Valley Flood Protection Plan Conservation Strategy for more details: http://www.water.ca.gov/conservationstrategy/docs/cs_draft.pdf.

[21]~~[17]~~ See the 2016 Draft Central Valley Flood Protection Plan Conservation Strategy for more details: http://www.water.ca.gov/conservationstrategy/docs/cs_draft.pdf.

[22]~~[18]~~ See the California State Parks Division of Boating and Waterways' Floating Aquatic Vegetation (FAV) ControlPrograms: http://www.dbw.ca.gov/?page_id=28995

[23]~~[19]~~ This reduction in invasive vegetation is based on efforts from large scale projects that address impacts of invasivespecies. This includes, but is not limited to: individual plans and projects that include treatment, California EcoRestore program, and project and non-project levee vegetation management. A full list of efforts will be described in the datasheet.

Output Performance Measures

Core Strategy 4.2: Restore Ecosystem Function

- **PM. 4.14. Increased funding for projects that possess attributes to restore ecosystem functions and support a resilient, functioning Delta ecosystem.**
  - **Metric:**
    - **Project funding of covered actions that file a certification of consistency under New ER Policy "A" (Disclose Contributions to Restoring Ecosystem Function). This metric excludes funding for projects that do not include protection, enhancement, or restoration of the Delta ecosystem. This metric will be reported annually.**
  - **Baseline:**
    - **Set at zero as of the effective date of New ER Policy "A."**
  - **Target:**
    - **By 2030, 80 percent of total funding for covered action projects that file certifications of consistency with New ER Policy "A" is for projects with Ecosystem Restoration Tier 1 or 2 attributes.**
- ~~Progress toward higher acreage of the following types: floodplain, tidal and subtidal, emergent wetland, shaded riverine aquatic and upland and riparian forest habitats. Tidal wetland and floodplain restoration projects should occur in the priority habitat restoration areas described in ER R2. (Strategy 4.2)~~

  ~~Metrics:~~

  ~~Number of acres of restoration projects constructed by habitat type, including progress toward the biological opinions' targets of restoring 8,000 acres of tidal wetlands and 17,000-20,000 acres of floodplain habitat in the Priority Restoration Habitat Areas.~~

  ~~Baseline:~~

  - ~~Set at zero, the number of acres restored as of the Delta Plan's adoption date (May 2013) to capture all the restoration actions that have been implemented after the plan was completed.~~

  ~~Target:~~

  - ~~8,000 acres of tidal wetlands and 17,000-20,000 acres of floodplain habitat projects constructed in the Priority Restoration Habitat Areas as described in the 2008 and 2009 Biological Opinions for the state and federal water projects.~~
- ~~All hatchery anadromous salmonids marked and tagged (Strategy 4.5)~~

  ~~Metrics:~~

- ~~Percent marked and tagged, as reported by National Marine Fisheries Service and California Department of Fish and Wildlife.~~

~~Baseline:~~

- ~~As of May 2013 (Delta Plan adoption date):~~
  - ~~100% marked and tagged for Chinook salmon winter-run, spring-run and late-fall run.~~
  - ~~25% marked and tagged for Chinook salmon fall-run.~~
  - ~~0% tagged and 100% marked for steelhead.~~

~~Target:~~

- ~~100% of hatchery fish are marked and tagged~~.

Core Strategy 4.3: Protect Land for Restoration and Safeguard Against Land Loss

- **PM 4.12. Subsidence reversal[24] activities are located at shallow subtidal elevations to prevent net loss of future opportunities to restore intertidal wetlands through tidal reconnection in the Delta and Suisun Marsh. (Core Strategy 4.3)**
  - **Metrics:**
    - **Acres of Delta and Suisun Marsh land with subsidence reversal activity located on islands with large areas at shallow subtidal elevations. This metric will be reported annually.**
    - **Average elevation accretion at each project site presented in centimeters per year. This metric will be reported every five years. Tracking will continue until a project is tidally reconnected.**
  - **Baseline:**
    - **In 2019, zero acres of subsidence reversal on islands with large areas at shallow subtidal elevations.**
    - **Soils in the Delta are subsiding at a rate of between 0 cm/year and 1.8 cm/year.**
  - **Target:**
    - **By 2030, 3,500 acres in the Delta and 3,000 acres in Suisun Marsh with subsidence reversal activities on islands with at least 50 percent of the area or at least 1,235 acres at shallow subtidal elevations.**
    - **For each project, an average elevation accretion of at least 4**

[24] **Subsidence reversal is a process that halts soil oxidation and accumulates new soil material in order to increase land elevations. Examples of subsidence reversal activities are rice cultivation, managed wetlands, and tidal marsh restoration**

centimeters per year until the project is tidally reconnected.

Core Strategy 4.4: Protect Native Species and Reduce the Impact of Nonnative Invasive Species

- **PM. 4.13. Remediate fish passage at priority barriers and select large rim dams in the Sacramento-San Joaquin River watershed, and screen priority diversions along native, anadromous fish migration corridors within the Delta.[25]**
  - **Metric:**
    - **Priority fish migration barriers and select large rim dams in the Sacramento-San Joaquin River watershed, and unscreened diversions along native, anadromous fish migration corridors in the Delta and Suisun Marsh. This metric will be evaluated annually.**
  - **Baseline:**
    - **Number of fish passage barriers, large rim dams, and unscreened diversions listed in:**
      - **CDFW 2018 Priority Barriers.**
      - **Central Valley Flood Protection Program (CVFPP) 2016 Conservation Strategy (Appendix K).**
      - **Large rim dams in the Sacramento–San Joaquin River watershed identified in the National Marine Fisheries Service's Central Valley Recovery Plan for Central Valley Salmon and Steelhead (2014) with recovery actions.**
      - **Unscreened diversions along Delta native, anadromous migration corridors listed in the Passage Assessment Database (PAD March 2018 version).**
  - **Target:**
    - **By 2030, remediate all (100 percent) priority barriers identified in the 2018 CDFW priority barriers list. For subsequent updates, remediate 100 percent within 10 years of being included in the priority barrier list.**
    - **By 2030, remediate all (100 percent) of the priority fish migration barriers listed in CVFPP 2016 Conservation**

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[25] ***Remediate*** **in this context means to provide passage upstream and downstream to migratory fish byconstructing, modifying, or removing a barrier.**

- **For rim dams, remediate means implementing a long-term fish passage program that may include, capture, transport, and release of fish at different life stages.**
- **For unscreened diversions, remediate means to screen the diversion so that juvenile and adultfish are physically protected from entrainment.**

Strategy.

- **By 2050, remediate fish passage at all (100 percent) large rim dams in the Sacramento-San Joaquin River watershed.**
- **By 2030, prioritize all (100 percent) unscreened diversions along native, anadromous fish migration corridors in the Delta, and by 2050 screen all (100 percent) priority diversions**

Administrative Performance Measures

Core Strategy 4.1: Create More Natural Functional Flows

- **PM ER R01-01. The State Water Resources Control Board adopts updates to the Bay-Delta Water Quality Control Plan, including updates to Delta outflow and Bay-Delta watershed tributary flow objectives, within one year of adoption of amendments to Chapter 4 of the Delta Plan.**
- ~~Prior to the establishment of revised flow objectives identified above, 100% of proposed actions that could significantly affect flow in the Delta are consistent with the existing Bay Delta Water Quality Control Plan objectives.~~
- ~~The SWRCB adopts Delta flow objectives that are necessary to achieve the coequal goals by June 2, 2014.~~
- ~~The SWRCB adopts flow objectives that are necessary to achieve the coequal goals for the major tributary rivers to the Delta by June 2, 2018.~~

Core Strategy 4.2: Restore Ecosystem Function~~Habitat~~

- ~~100% of proposed actions that include habitat restoration in the Delta meet one of the following standards: 1) are consistent with the text of Appendix H, based on the *Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions* (DFG 2011); or 2) are not consistent with the elevation map (Figure 4-6), but the deviation is supported by a rationale based on best available science.~~
- ~~100% of all proposed actions other than habitat restoration have clearly demonstrated that significant adverse impacts to the opportunity for habitat restoration as described in ER P2 were avoided or mitigated.~~
- ~~100% of proposed actions to construct new levees or substantially rehabilitate or reconstruct existing levees in the opportunity areas defined in Appendix 8, demonstrate that they have evaluated alternatives (including use of setback levees), and where feasible, have incorporated such alternatives into levee projects to increase the extent of floodplain and riparian habitat.~~
- ~~DFW, DWR, and/or the Delta Conservancy identify number of projects and amount of funding for priority habitat restoration projects.~~
- ~~The preponderance of proposed habitat restoration projects is within the six priority areas and considers landscape elements and improvement in water~~

~~quality.~~

- ~~100% of proponents of habitat restoration projects consult the California Department of Public Health's *Best Management Practices for Mosquito Control in California*.~~
- ~~The Delta Conservancy develops and adopts criteria for prioritization and integration of large- scale ecosystem restoration in the Delta and Suisun Marsh, with sustainability and use of best available science as foundational principles.~~
- ~~The Delta Conservancy develops and adopts processes for ownership and long-term operations and management of land in the Delta and Suisun Marsh acquired for conservation or restoration.~~
- ~~The Delta Conservancy develops and adopts a formal mutual agreement with the Department of Water Resources, Department of Fish and Wildlife, federal interests, and other State and local agencies on implementation of ecosystem restoration in the Delta and Suisun Marsh.~~
- ~~The Delta Conservancy develops a plan and protocol for acquiring the land necessary to achieve ecosystem restoration consistent with the coequal goals and the Ecosystem Restoration Program's Delta Conservation Strategy.~~
- ~~The Delta Conservancy leads an effort to investigate how to better use habitat credit agreements.~~
- ~~The Delta Conservancy, in conjunction with DFW and USFWS, develop rules for voluntary Safe Harbor Agreements with property owners in the Delta.~~
- **PM ER RB-01. 100 percent of proposed actions that include ecosystem protection, enhancement, or restoration use the California Department of Water Resources (DWR) Good Neighbor Checklist to avoid or reduce conflicts with existing uses**.
- **PM ER R4-01.** The U.S. Army Corps of Engineers develops an agreed-upon variance process to exempt Delta levees from the U.S. Army Corps of Engineers' levee vegetation policy where appropriate.

[Next four performance measures moved to Core Strategy 3]

- ~~BCDC updates the Suisun Marsh Protection Plan to address adaptation to sea-level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act and the Delta Plan.~~
- ~~BCDC submits amendments of the Suisun Marsh Protection Plan to the Council for review for consistency.~~
- ~~BCDC submits amendments of components of the Suisun Marsh Local Protection Program to the Council for review for consistency.~~
- ~~BCDC adopts the updated Suisun Marsh Protection Plan and the Suisun Marsh Local Protection Program.~~

Core Strategy 4.3: Protect Land for Restoration and Safeguard Against Land Loss~~Improve Water Quality to Protect the Ecosystem~~

- **PM ER RC-01. The Sacramento–San Joaquin Delta Conservancy (Delta Conservancy) develops incentive programs for public and private landowners which encourage land management practices that stop subsidence on deeply subsided lands in the Delta and Suisun Marsh.**
- **PM ER RC-02. State investments in ecosystem restoration in subsided areas, coordinated by DWR, CDFW, and the Delta Conservancy, are directed at projects that both reverse subsidence and restore intertidal marsh habitat.**
- **PM ER RD-01. The California Legislature provides state agencies with funding to provide resources, and support to resource conservation districts, reclamation districts, and other local agencies and districts, to restore ecosystem function or improve agricultural land management practices that support native species.**
- **PM ER RD-02. DWR, CDFW, the Delta Protection Commission, the Delta Conservancy, and other state agencies work with local resource conservation districts and other local agencies and districts to adaptively manage agricultural land management practices to improve habitat conditions for native bird and fish species.**
- **PM ER RE-01. State and local agencies have developed management plans for all publicly owned lands in the Delta or Suisun Marsh, which address subsidence and consider the feasibility of subsidence reversal.**
- **PM ER RE-02. For all publicly owned lands in the Delta or Suisun Marsh, State and local agencies, including Reclamation Districts, should develop or update plans that identify land management goals, identify appropriate public or private uses for the land, and describe the operation and maintenance requirements needed to implement management goals. These activities address subsidence and consider the feasibility of subsidence reversal.**
- ~~See Chapter 6: Water Quality.~~

[Next four performance measures moved from Core Strategy 3]

- **PM ER R05-01. The San Francisco Bay Conservation and Development Commission (**BCDC**)** updates **and certifies components of** the Suisun Marsh Protection Plan to address adaptation to sea-level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act**,** and the Delta Plan.
- **PM ER R05-02.** The BCDC submits amendments of the Suisun Marsh Protection Plan to the Council for review, for consistency.
- **PM ER R05-03. The** BCDC **supports local governments and districts with jurisdiction in the Suisun Marsh in amending their** ~~submits amendments of~~ components of the Suisun Marsh Local Protection Program to **submit to** the Council for review**,** for consistency **with the Delta Plan.**

- **PM ER R05-04. The** BCDC adopts the updated Suisun Marsh Protection Plan and **certifies components of** the Suisun Marsh Local Protection Program. **that are consistent with the Delta Plan.**

Core Strategy 4.4: Protect Native Species and Reduce the Impact ofPrevent Introduction of and Manage Nonnative Invasive Species Impacts

- **PM ER RH-1. CDFW prioritizes unscreened diversions in the Delta for remediation.**
- **PM ER RI-1. Public agencies fund and implement projects that improve aquatic habitat conditions and reduce predation risk for juvenile salmon.**
- 100% of all proposed actions that have the reasonable probability of introducing, or improving the habitat conditions for, nonnative invasive species have demonstrated that the potential for new introductions of and/or improved habitat conditions for nonnative invasive species have been fully considered and avoided or mitigated in a way that appropriately protects the ecosystem.
- The Department of Fish and Wildlife develops for consideration by the Fish and Game Commission proposals for new or revised fishing regulations designed to increase populations of listed fish species through reduced predation by introduced sport fish.
- **PM ER R07-01.** The Department of Fish and Wildlife and other appropriate agencies prioritize the list of "Stage 2 Actions for Nonnative Invasive Species." **The Delta Conservancy, Council's Delta Science Program, CDFW, California Department of Food and Agriculture, California Department of Parks and Recreation, Division of Boating and Waterways, and other state and federal agencies, develop and implement communication strategies, based on scientific expertise, to manage existing nonnative invasive species and for rapid response to address introductions of nonnative invasive species.**
- **PM ER R07-02.** The Department of Fish and Wildlife and other appropriate agencies fully implement the 2014 Ecosystem Restoration Program "Conservation Strategy" list for Strategic Goal 5. **The Delta Conservancy, Council's Delta Science Program, CDFW, California Department of Food and Agriculture, California Department of Parks and Recreation, Division of Boating and Waterways, and other state and federal agencies, develop and implement funding strategies, based on scientific expertise, to manage existing nonnative invasive species and for rapid response to address introductions of nonnative invasive species.**
- **PM ER R8-01.** Hatcheries develop scientifically sound Hatchery and Genetic Management Plans (HGMPs). **CDFW and the USFWS ensure hatcheries develop, or continue to develop, periodically update, and implement scientifically sound Hatchery and Genetic Management Plans (HGMPs).**
- **PM ER R9-01.** The Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service revises and begins implementing its program for marking and tagging hatchery

~~salmon and steelhead to improve management of hatchery and wild stocks by December 2014.~~ **The CDFW, in cooperation with the USFWS and the National Marine Fisheries Service, should seek coordination among researchers studying juvenile anadromous fish migration pathways and survival upstream of, and within the Delta waterways to improve synthesis of results across research efforts and application to adaptive management actions.**

Core Strategy 4.5: Improve Institutional Coordination to Support Implementation of Ecosystem Protection, Restoration, and Enhancement~~Hatcheries and Harvest Management~~

- ~~Hatcheries develop scientifically sound Hatchery and Genetic Management Plans (HGMPs).~~
- ~~The Department of Fish and Wildlife provides annual updates to the Council on the status of HGMPs within its jurisdiction.~~
- ~~The Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service revises and begins implementing its program for marking and tagging hatchery salmon and steelhead to improve management of hatchery and wild stocks by December 2014.~~
- **PM ER RF-02. The Delta Plan Interagency Implementation Committee (DPIIC) develops strategies for acquisition and long-term ownership and management of lands necessary to achieve ecosystem restoration, consistent with the guidance in Appendix Q2.**
- **PM ER RF-03. DPIIC develops a funding strategy that identifies a portfolio of approaches to remove institutional barriers and fund Ecosystem Restoration Tier 1 or 2 actions within the Delta.**
- **PM ER RF-04. DPIIC establishes program-level endangered species permitting mechanisms that increase efficiency for Ecosystem Restoration Tier 1 or 2 actions within the Delta and compatible ecosystem restoration projects within the Delta watershed.**
- **PM ER RF-05. DPIIC coordinates with the Delta Science Program to align state, federal, and local resources for scientific support of restoration efforts, including adaptive management, data tools, monitoring, synthesis, and communication.**
- **PM ER RF-06. DPIIC develops a landscape-scale strategy for recreational access to existing and future restoration sites, where appropriate, and while maintaining ecological value.**
- **PM ER RG-01. DPIIC coordinates alignment of state, local, and regional restoration strategies, plans, or programs in the Delta to be consistent with the priority attributes described in Appendix Q2.**

Chapter 5: Protect and Enhance the Unique Cultural, Recreational, Natural Resource, and Agricultural Values of the California Delta as an Evolving Place

Core Strategy 5.1: Designate the Delta as a Special Place

Core Strategy 5.2: Plan to Protect the Delta's Lands and Communities

Core Strategy 5.3: Maintain Delta Agriculture

Core Strategy 5.4: Encourage Recreation and Tourism

Core Strategy 5.5: Sustain a Vital Delta Economy

Outcome Performance Measures

Core Strategy 5.2: Plan to Protect the Delta's Lands and Communities

- **PM 5.2.** Increase acres with subsidence reversal or carbon sequestration practices. (Strategy 5.2)
  - Metrics:
    - Acres of subsidence reversal and carbon sequestration projects, evaluated annually.
  - Baseline:
    - Set at zero as of 2008.
  - Target:
    - 30,000 acres by January 1, 2030 (905 acres were converted in 2008-2011 and will be included towards meeting the target).
- **PM 5.3.** No change in agricultural land use due to urban development from 2013–2025.[26][20] (**Also applies to Core** Strategy 5.2, 5.3)
  - Metrics:

    Metrics to be evaluated annually:
    - Conversion of farmland acres to urban development, evaluated in conjunction with updates to the Farmland Mapping and Monitoring Program.[27][21]

[26][20]The importance of agricultural lands, as they relate to wildlife habitat and ecosystem restoration, will be addressedthrough future Delta Plan review and amendment processes.

[27][21] As identified in the Farmland Mapping and Monitoring Program (FMMP), including Prime Farmland, UniqueFarmland, Farmland of Statewide Importance, Farmland of Local Importance, and Grazing Land.

    - Conversion of land designated for agricultural use to urban land use, under General Plan land designations, evaluated annually.
  - Baseline:
    - Number of acres of Delta rural farmland designated for agriculture in Delta Plan regulations, at the time of Delta Plan adoption in May of 2013.
  - Target:
    - By 2025, no conversion of farmland to urban development as defined by Delta Plan regulations.

Core Strategy 5.4: Encourage Recreation and Tourism

- **PM 5.8.** Increase in delta recreation and tourism trends.[28][22] ~~(Strategy 5.4)~~
  - Metrics:

    Metrics evaluated annually:
    - Acres of State and federal land accessible by the public for recreation and tourism.
    - Length (linear feet) of shoreline accessible for public recreation.
    - Number of fishing licenses bought per year by county.
    - Number of first-time visitors.
    - Number of off-season visitors.
    - Number of website views and social media traffic.
    - Number of existing and new visitor engagement.
  - Baseline:
    - Measured as of July 2018.
  - Target:
    - Increase of 5 percent, for each metric from the prior year, over a 5-year period beginning once a baseline is established in 2018.
- **PM 5.6.** Increase in regional recreation opportunities throughout the Delta and Suisun Marsh. ~~(Strategy 5.4)~~
  - Metrics:
    - Number of regional Recreation Proposal recommendations and

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Department ofConservation (http://www.conservation.ca.gov/dlrp/fmmp).

[28][22] Data will be tracked as part of the collaboration between the Delta Marketing Task Force, Sacramento-San Joaquin Delta Conservancy, Delta Protection Commission, and Delta Stewardship Council, in an effort to implementthe objectives of the *Delta Tourism Awareness 5-year Marketing Plan*, released February 2017: http://deltaconservancy.ca.gov/wp-content/uploads/2015/06/AI-12.2-Marketing-Plan-Design_Complete- 20170224.pdf.

outcomes implemented within the Delta and Suisun Marsh, evaluated annually.[29][23]

- Baseline:
  - Measured as of the date of the regional Recreation Proposal completed in 2011.
- Target:
  - Implementation of the recommendations and outcomes put forward within the Recreation Proposal, to be achieved by 2025.

Core Strategy 5.5: Sustain a Vital Delta Economy

- **PM 5.9.** Improvement in the Regional Opportunity Index within the Delta.[30][24] (**Also applies to Core** Strategy 5.3~~, 5.5~~)
  - Metrics:
    - Metrics to be evaluated every 5 years:
    - Regional Opportunity Index for People and Place, in the Primary Zone and Secondary Zone (score).
  - Baseline:
    - Measured as of 2012.
  - Target:
    - Regional Opportunity Index for People and Place (score), within the Delta, increases by 5 percent by 2025.[31][25]

Output Performance Measures

Core Strategy 5.2: Plan to Protect the Delta's Lands and Communities

- **PM 5.5.** Prepare and implement plans for the vitality and preservation of each Delta legacy community. ~~(Strategy 5.2)~~
  - Metrics:
    - Number of community action plans adopted and initiated to

[29][23] The UC Davis Center for Regional Change will be releasing new information and features for the Regional Opportunity Index (ROI) (http://interact.regionalchange.ucdavis.edu/roi/webmap/webmap.html) which will provide the foundation to refine targets for the Delta; periodic evaluation of targets may be required in collaboration with theDelta Protection Commission

[30][24] Developed by the Center for Regional Change at UC Davis, this index incorporates 33 indicators that measure relative opportunity, for both people and the places in which they live, and focuses on six broad domains: education,economy, housing, transportation/mobility, health/environment, and civic engagement.

[31][25] Recommendations and outcomes proposed by California Department of Parks and Recreation in Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh, per 2009 Delta Reform Act legislative directive(http://www.parks.ca.gov/?page_id=26677).

achieve legacy community Delta Plan objectives, evaluated annually.

- Baseline:
  - Set at zero as of the Delta Plan's adoption date, May 2013.
- Target:
  - All legacy communities have plans adopted by 2021.
  - 25 percent implementation of plan objectives achieved by 2025.

Administrative Performance Measures

Core Strategy 5.1: Designate the Delta as a Special Place

- Delta Protection Commission completes application for designation of the Delta and Suisun Marsh as a National Heritage Area.
- The California Department of Transportation prepares a scenic byway plan and pursues National Scenic Byway status for Route 160 by January 1, 2014.
- Congress designates a National Heritage Area that includes the Delta and Suisun Marsh by January 1, 2014.

Core Strategy 5.2: Plan to Protect the Delta's Lands and Communities

- 100% of proposed actions for urban development meet one of the following standards: 1) are located within areas that current city or county general plans as of the date of the Delta Plan's adoption designate for development in cities or their spheres of influence; areas within Contra Costa County's 2006 voter-approved urban limit line, except Bethel Island; areas within the Mountain House General Plan Community Boundary in San Joaquin County; or the unincorporated Delta towns of Clarksburg, Courtland, Hood, Locke, Ryde and Walnut Grove; 2) if located on Bethel Island, are consistent with the Contra Costa County general plan effective as of the date of the Delta Plan's adoption; or 3) if located outside the areas described above, are consistent with the land uses designated in county general plans as of the date of the Delta Plan's adoption and are otherwise consistent with Delta Plan policies.
- Water management facilities, ecosystem restoration, and flood management infrastructure are sited to avoid or reduce conflicts with existing or planned uses when feasible, considering comments from local agencies and the Delta Protection Commission. Plans for ecosystem restoration consider sites on existing public lands, when feasible and consistent with a project's purpose, before privately owned sites are purchased.
- Local governments prepare plans for each community that emphasize its distinctive character, encourage historic preservation, identify opportunities to encourage tourism, serve surrounding lands, or develop other appropriate uses, and reduce flood risks.
- Agencies acquiring land for water management facilities, ecosystem restoration,

and flood management infrastructure purchase from willing sellers, when feasible, including consideration of whether lands suitable for proposed projects are available at fair prices.

- The California Department of Transportation, local agencies, and utilities develop plans infrastructure, such as roads and highways, to meet needs of development consistent with sustainable community strategies, local plans, Delta Protection Commission's Land Use and Resource Management Plan, and the Delta Plan.
- As part of the prioritization of State levee investments called for in RR P4, the Delta Stewardship Council consults with the California Department of Transportation as provided in Water Code section 85307(c) to consider the effects of flood hazards and sea level rise on state highways in the Delta.
- The Council, in conjunction with the California Air Resources Board (CARB) and the Delta Conservancy, investigates the opportunity for the development of a carbon market whereby Delta farmers could receive credit for growing native marsh and wetland plants.
- The Department of Water Resources has developed a plan, including funding needs, for increasing the extent of their subsidence reversal and carbon sequestration projects to 5,000 acres by January 1, 2017.
- 100% of State agencies have not renewed or entered into agricultural leases on Delta or Suisun Marsh islands if the actions of the lessee promote or contribute to subsidence on the leased land, unless the lessee participates in subsidence reversal or reduction programs.

Core Strategy 5.3: Maintain Delta Agriculture

- Local governments and economic development organizations take steps to encourage value-added processing of Delta crops in appropriate locations.
- Local governments and economic development organizations take steps to support growth in agritourism, particularly in and around legacy communities.
- The Department of Fish and Wildlife, the Delta Conservancy, and ecosystem restoration agencies take steps to encourage habitat enhancement and wildlife friendly farming systems on agricultural lands to benefit both the environment and agriculture.

Core Strategy 5.4: Encourage Recreation and Tourism

- Water management and ecosystem restoration agencies provide recreation opportunities, including visitor-serving business opportunities, at new facilities and habitat areas whenever feasible, and protect existing recreation facilities using California State Parks' *Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh* and Delta Protection Commission's *Economic Sustainability Plan* as guides.
- The Delta Protection Commission and Delta Conservancy take steps to encourage partnerships between other state and local agencies, and local

landowners and business people to expand recreation, including boating, promote tourism, and minimize adverse impacts to non-recreational landowners.

- Dedicated funding sources are identified to add of improve recreation facilities in the Delta.
- The Department of Fish and Wildlife, in cooperation with other public agencies, should collaborate with nonprofits, private landowners, and business partners to expand wildlife viewing, angling, and hunting opportunities.
- The Department of Boating and Waterways coordinates with the U.S. Coast Guard and State and local agencies on an updated marine patrol strategy for the region.
- Public agencies owning land increase opportunities, where feasible, for bank fishing, hunting, levee top trails, and environmental education.
- Cities, counties, and other local and state agencies work together to protect and enhance visitor serving businesses by planning for recreation uses and facilities in the Delta, providing infrastructure to support recreation and tourism, and identifying settings for private visitor- serving development and services.

Core Strategy 5.5: Sustain a Vital Delta Economy

- The ports of Stockton and West Sacramento encourage maintenance and carefully designed and sited development of port facilities.
- The Energy Commission and Public Utilities Commission cooperate with the Delta Stewardship Council as described in Water Code section 85307(d) and identify actions that should be incorporated in the Delta Plan to address the needs of Delta energy development, storage, and distribution by 2017.

Chapter 6: Improve Water Quality to Protect Human Health and the Environment

Core Strategy 6.1: Require Delta-Specific Water Quality Protection

Core Strategy 6.2: Protect Beneficial Uses by Managing Salinity

Core Strategy 6.3: Improve Drinking Water Quality

Core Strategy 6.4: Improve Environmental Water Quality

Outcome Performance Measures

Core Strategy 6.1: Require Delta-Specific Water Quality Protection

- **PM 6.1.** Water quality in the Delta and Suisun Marsh meets the standards of the Clean Water Act. ~~(Strategy 6.1)~~
  - Metrics:
    - The number of Delta watershed waterbody-contaminant combinations on the 303(d) list, evaluated every 8 years within the State Water Resources Control Board Integrated Report.
  - Baseline:
    - Measured as of the 2010 Integrated Report.[32]~~[26]~~
  - Target:
    - Reduction of 40 percent of the waterbody-contaminant combinations on the 303(d) list by 2034.

Core Strategy 6.2: Protect Beneficial Uses by Managing Salinity

- **PM 6.2.** Water management agency compliance with State Water Resources Control Board objectives for salinity in the Delta for D-1641 and X2.[33]~~[27]~~ ~~(Strategy 6.2)~~
  - Metrics:
    - Monthly electrical conductivity and water temperature, and X2 in the Delta, evaluated annually.

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[32]~~[26]~~ State Water Resources Control Board, 2010 Integrated Report—Clean Water Act Section 303(d) List/305(b) Report (http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml); to be prepared on a tri-region cycle every 2 years, with data available for each region on an 8-year interval.

[33]~~[27]~~ X2 is the distance from the Golden Gate Bridge to the point where daily average salinity is 2 parts per thousand at1 meter off the bottom (Jassby et al., 1995). http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/usdoi/spprt_docs/doi_jassby_1994.pdf.

- Baseline:
    - Average monthly electrical conductivity and water temperature, and X2, at compliance points from 1995 to 2015.
- Target:
    - Targets are to be achieved upon the adoption of these performance measures.[34]~~[28]~~
        - Water management agencies meet State Water Resources Control Board salinity objectives for ecosystem purposes, at least 99 percent of the time, at compliance points.
        - Water management agencies meet all other State Water Resources Control Board salinity objectives for urban and agricultural beneficial use, at least 99 percent of the time, at compliance points.
        - Water management agencies maintain average X2, for September and October, at or less than 74 km in the fall following wet years, and at or less than 81 km in the fall following above normal years. The monthly average X2 must be maintained at or seaward of these values for each individual month, and cannot be averaged over the two-month period.[35]~~[29]~~

Core Strategy 6.4: Improve Environmental Water Quality

- **PM 6.5.** Consistently meeting applicable dissolved oxygen (DO) standards in the Delta by 2020 (i.e., Stockton Deep Water Ship Channel, Suisun Marsh, and Old and Middle River). ~~(Strategy 6.4)~~
    - Metrics:

      Progress of PM metrics are to be evaluated annually:
        - Milligrams of DO per liter of water (mg/L).
        - Continuous, real-time DO measurements made at multiple locations throughout the Delta.
    - Baseline:
        - Measured as of the date of the Delta Plan's adoption, May 2013.
    - Target:
        - Targets to be achieved upon the adoption of this performance

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[34]~~[28]~~ The targets are to be met during periods when Temporary Urgency Change Petitions (TUCPs) are not in effect(e.g., TUCPs may be in effect during severe drought).

[35]~~[29]~~ The standards of 74 km in wet years, and 81 km in above normal years, are designed to mitigate the effects of X2 encroachment upstream, in current and proposed action operations, and to provide suitable habitat for organisms using this low-salinity region. The target is referenced in the Biological Opinions: https://www.fws.gov/sfbaydelta/documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf.

measure:

- Meet water quality objectives for DO in the Stockton Deep Water Ship Channel, Suisun Marsh, and Old and Middle River.
- Maintain or exceed the minimum DO concentrations of[36]~~[30]~~
  - 5 mg/L daily average everywhere in the Delta.
  - 6 mg/L daily average, from September through November, only in the San Joaquin River between Turner Cut and Stockton.

- **PM 6.9.** Measurable reduction in positive toxicity tests, using standard methods, for pesticides and other pollutants in Delta waters. ~~(Strategy 6.4)~~
  - Metrics:
    - Toxicity in sediments using invertebrates determined by standard methods approved by the USEPA, as measured by the State Water Resources Control Board.[37]~~[31]~~
  - Baseline:
    - The 2008-2012 averaged levels of toxicity using combined Toxic and Highly toxic sites from the Stream Pollution and Monitoring Program Report (18.8% toxicity).
  - Target:
    - Less than 1 percent toxicity in sediment samples from pesticides and other contaminants, using invertebrate testing, by 2034.
- **PM 6.10.** Reduced spatial coverage of freshwater harmful algal blooms in waterbodies in the Delta. (**Also applies to Core** Strategy 6.1~~, 6.4~~)
  - Metrics:

    Progress of PM metrics are to be evaluated annually:
    - Spatial coverage (acres) of Microcystis sp. cell concentration equivalents (cells/ml), in Delta waterbodies large enough to use the SWRCB mapping tool[38]~~[32]~~ (e.g., Discovery Bay; South Delta along Grantline Canal and Old River surrounding Fabian Tract;

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[36]~~[30]~~ DO concentration can peak during daylight hours and drop during nighttime hours. As a result, a daily and/or monthly average needs to consistently meet TMDL standards in the Delta.

[37]~~[31]~~ The Stream Pollution Trends Monitoring Program monitors trends in toxicity and pollution for California waters, and was implemented in 2008.

[38]~~[32]~~ The State Water Resources Control Board is in the process of finalizing an interactive mapping tool used for displaying estimated concentrations of cyanobacteria in large water bodies. The satellite tool will use data from the new Sentinel3b satellite, which detects the absorption of chlorophyll in phytoplankton and provides an estimate of chlorophyll-a concentration and can detect the presence of phycocyanin. This data can then be used to calculate the portion of the biomass associated with cyanobacteria and non-cyanobacteria. Estimates for the average baseline reported between 2016-2017 will be calculated upon the tool's release date (expected November 2017).

Big Break Regional Shoreline; and San Joaquin River between Antioch and Stockton) with densities of 100,000 cell/ml[39][33] or greater.

- Baseline:
  - Spatial coverage (acres) based on satellite images during the period of 2016– 2017.
- Target:

  Target to be achieved by 2034:
  - Zero acres of waterbodies with densities of 100,000 cells/ml.[40][34]

Output Performance Measures

Core Strategy 6.3: Improve Drinking Water Quality

- **PM 6.3.** Implementation of the North Bay Aqueduct Alternate Intake Project to improve water quality, protect native fishes, and to provide reliable water deliveries. ~~(Strategy 6.3)~~
  - Metrics:
    - Project status.
  - Baseline:
    - The Notice of Preparation for the North Bay Aqueduct Alternate Intake Project Environmental Impact Report was published on November 24, 2009.
  - Target:
    - The Department of Water Resources, in collaboration with beneficiaries, would begin constructing the North Bay Aqueduct Alternate Intake Project by the end of 2019.
- **PM 6.4.** Protect groundwater beneficial uses. Groundwater meets drinking water quality standards in the Delta for levels of nitrate (10 ppm NO3-N) and arsenic (10 ppb As). ~~(Strategy 6.3)~~
  - Metrics:
    - Number of groundwater wells used for drinking water supply that exceed arsenic and/or nitrate drinking water limits, evaluated every 5 years.

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[39][33] The tool for maintaining spatial images and cell count can be found through the SWRCB Cyanobacteria and Harmful Algal Bloom Network page: http://www.mywaterquality.ca.gov/habs/where/satellite.html. The tool is expected to be released in November 2017, and baseline satellite images will begin between 2016-2017.

[40][34] Cell densities exceeding the 100,000 cells/ml threshold constitute a high-risk exposure, with an increased probability of irritative symptoms of exposure and potential health impacts. See the WHO guideline values for relative probability of acute health effects.

- Baseline:
  - Number of wells within the Delta which exceed 2008 California water quality standards for levels of nitrate (not to exceed 10 ppm NO3-N) and arsenic (not to exceed 10 ppb As), between the years of 2001–2013.
- Target:
  - A 50 percent reduction in the number of wells exceeding nitrate and arsenic standards from baseline levels, using historical data from 2001–2013, achieved by 2034.

<u>Core Strategy 6.4: Improve Environmental Water Quality</u>

- **<u>PM 6.7.</u>** Reduction in number of critical pesticides in the waters and sediments of the Delta and Suisun Marsh. ~~(Strategy 6.4)~~
  - Metrics:
    - The number of Delta watershed waterbody-pesticide combinations on the 303(d) list, as evaluated every 8 years within the State Water Resources Control Board Integrated Report.
  - Baseline:
    - Number of waterbody-pesticide combinations on the 303(d) list reported in the 2010 Integrated Report.[41]~~[35]~~
  - Target:
    - Zero Delta watershed waterbody-pesticide combinations on the 303(d) list by 2034.
- **<u>PM 6.8.</u>** Reducing concentrations and/or loads of bio-stimulatory substances in Delta waters. ~~(Strategy 6.4)~~
  - Metrics:
    - Concentration and/or loads of bio-stimulatory substances (in organic nutrients such as ammonium, nitrate, and phosphate) Delta water quality monitoring locations, evaluated annually.
  - Baseline:
    - Bio-stimulatory substance concentrations, loads, and trends during the period of 2004-2013.
  - Target:
    - Meet the limits and targets identified by the Delta Nutrient Science and Research Program[42]~~[36]~~ by 2034.

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[41]~~[35]~~ State Water Resources Control Board, 2010 Integrated Report—Clean Water Act Section 303(d) List/305(b) Report (http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml); to be prepared on a tri- region cycle every 2 years, with data available for each region on an 8-year interval.
[42]~~[36]~~ The State and Regional Water Resources Control Board are finalizing research prioritization and

Administrative Performance Measures

Core Strategy 6.1: Require Delta-Specific Water Quality Protection

- There is no administrative performance measure for this policy at this time.
- 100% of covered actions that affect water quality in the Delta identify any significant negative water quality impacts.
- SWRCB and RWQCBs evaluate and include appropriate protections in any applicable water quality control plan.

Core Strategy 6.2: Protect Beneficial Uses by Managing Salinity

See Chapter 4 Strategy 1: Create More Natural Functional Flows

Core Strategy 6.3: Improve Drinking Water Quality

- Central Valley RWQCB completes the Central Valley Drinking Water Policy by July 2013.
- The Department of Water Resources completes the North Bay Aqueduct Alternate Intake Project EIR by July 1, 2012.
- SWRCB completes development of a Strategic Workplan for protection of groundwater beneficial uses by December 31, 2012.
- Central Valley RWQCB and SWRCB adopt policies and regulations necessary to require all relevant water users that are supplied water from the Delta or the Delta Watershed or discharge wastewater to the Delta or the Delta Watershed to participation in CV-SALTS.

Core Strategy 6.4: Improve Environmental Water Quality

- SWRCB develops a proposed policy for nutrients for Inland Surface Waters of the State of CA by January 1, 2014.
- SWRCB and RWQCBs begin implementation of a study plan for the development of objectives for nutrients in the Delta and Suisun Marsh by January 1, 2013, and complete studies by January 1, 2016.
- SWRCB and RWQCBs adopt objectives for nutrients in the Delta by January 1, 2018.
- TMDLs and Basin Plan Amendments for diazinon and chlorpyrifos are completed by January 1, 2013.
- The Central Valley Pesticide TMDL is completed by January 1, 2016.

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scientific work which will provide the foundation for interim targets addressing bio-stimulatory substances (e.g., Delta Nutrient Research Plan, Biological Integrity Assessment Project, and Bio-stimulatory Substances Project, to be completed in 2018). Future evaluation of targets may be required in the case of rulemaking processes and resulting regulations by SWRCB. (http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/).

- SWRCB and RWQCBS complete TMDLs and Basin Plan Amendments for methylmercury.
- The Central Valley Regional Water Quality Control Board review the methyl mercury control studies by December 31, 2018 and determine control measures for implementation starting

  in 2020.
- A Delta regional water quality monitoring program is developed.
- A Delta regional monitoring program is implemented within the first 5 years of the Delta Plan.
- The Central Valley Regional Water Quality Control Board requires responsible entities that discharge wastewater treatment plant effluent or urban runoff to Delta waters to evaluate whether all or a portion of the discharge can be recycled, otherwise used, or treated in order to reduce contaminant loads to the Delta by January 1, 2014.
- The State Water Resources Control Board and the Central Valley Regional Water Quality Control Board complete the Phase 2 control plan for the Total Maximum Daily Load and Basin Plan Amendment for dissolved oxygen in the Stockton Ship Channel by January 1, 2015.
- The State Water Resources Control Board and the San Francisco Bay Regional Water Quality Control Board complete the Total Maximum Daily Load and Basin Plan Amend

Chapter 7: Reduce Risk to People, Property, and State Interests in the Delta

Core Strategy 7.1: Improve Emergency Preparedness and Response

Core Strategy 7.2: Finance and Implement Local Flood Management Activities

Core Strategy 7.3: Prioritize Flood Management Investment

Core Strategy 7.4: Improve Residential Flood Protection

Core Strategy 7.5: Protect and Expand Floodways, Floodplains, and Bypasses

Core Strategy 7.6: Integrate Delta Levees and Ecosystem Function

Core Strategy 7.7: Limit State Liability

Outcome Performance Measures

Core Strategy 7.1: Improve Emergency Preparedness and Response

- **PM 7.2.** Decrease in expected annual fatalities and expected property damages from flood emergencies in the Delta ~~(Strategy 7.1)~~
    - Metrics:
        - Expected Annual Fatalities (EAF) in the Delta. This will be evaluated at least every 5 years.
        - Expected Annual Damages (EAD) in the Delta. This will be evaluated at least every 5 years.
    - Baseline:
        - EAF for the Delta using best available data as of 2017, as reported in the Delta Levees Investment Strategy final report.
        - EAD for the Delta using best available data as of 2017, as reported in the Delta Levees Investment Strategy final report.
    - Target:
        - 50 percent decrease in EAF by 2025.
        - 50 percent decrease in EAD by 2025.

Core Strategy 7.3: Prioritize Flood Management Investment

- **PM 7.5.** Water-delivery interruptions due to floods or earthquakes in the Delta. ~~(Strategy 7.3)~~
    - Metrics:
        - Number of water-delivery interruptions caused by floods or earthquakes in the Delta. This performance measure will be

    assessed following any major floods or earthquakes in the Delta
    - Acre-feet of water not delivered due to disruptions caused by floods or earthquakes in the Delta. This performance measure will be assessed following any major floods or earthquakes in the Delta
  - Baseline:
    - N/A because this measure has a prescribed target and is not showing a change from a baseline.
  - Target:
    - No water delivery interruptions. This target is to be achieved upon the adoption of this performance measure.
- **PM 7.7.** Increase in community credit points in National Flood Insurance Program (NFIP) Community Rating System. (**Also applies to Core** Strategy 7.**7**~~8~~)
  - Metrics:
    - Community Rating System credit points of Delta communities participating in the NFIP. This will be evaluated at least every 5 years.
  - Baseline:
    - Community Rating System credit points at the time of Delta Plan adoption in May 2013, or nearest available date.
  - Target:
    - 1 percent increase in Community Rating System credit points by 2025.

Output Performance Measures

Core Strategy 7.1: Improve Emergency Preparedness and Response

- **PM 7.1.** Responsible local, State, and federal agencies with emergency response authority, implement the recommendations of the Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force (Water Code section 12994.5) by end of 2018. ~~(Strategy 7.1)~~
  - Metric:
    - Percent of recommendations implemented. This will be evaluated annually.
  - Baseline:
    - Zero percent (0/11) of recommendations implemented.
  - Target:
    - 100 percent (11/11) of recommendations implemented by the end of 2018.

Core Strategy 7.3: Prioritize Flood Management Investment

- **PM 7.3.** Level of flood-risk reduction provided by Delta levees. ~~(Strategy 7.3)~~
  - Metrics:
    - Percent of urban area in the Delta protected by levees meeting DWR's urban level of flood protection criteria. This will be evaluated at least every 5 years.
    - Percent of rural Delta islands and tracts protected by levees at or above the Bulletin 192-82/PL 84-99 standard. This will be evaluated at least every 5 years.
  - Baseline:
    - Percent of urban area in the Delta protected by levees meeting DWR's urban level of flood protection criteria, as of completion of the Delta Levees Investment Strategy.
    - Percentage of rural Delta islands and tracts protected by levees at or above the Bulletin 192-82/PL 84-99 standard, as of completion of the Delta Levees Investment Strategy.
  - Target:
    - 100 percent of urban communities in the Delta are protected by levees meeting DWR's urban level of flood protection criteria, demonstrated by 2025.
    - 100 percent of the rural Delta islands and tracts are protected by levees at or above the Bulletin 192-82/PL 84-99 standard, demonstrated by 2050.

Core Strategy 7.5: Protect and Expand Floodways, Floodplains, and Bypasses

- **PM 7.6.** Consideration of sea level rise in flood protection planning for new residential development in the Delta. ~~(Strategy 7.5)~~
  - Metric:
    - Number of proposed actions covered by the Delta Plan policy to require flood protection for residential development in rural areas (RR P2). This performance measure will be evaluated as covered actions are submitted.
  - Baseline:
    - N/A because this measure has a prescribed target and is not showing a change from a baseline.
  - Target:
    - 100% of proposed actions to which RR P2 are applicable meet the requirements of RR P2. This target is to be achieved upon the adoption of this performance measure.

Administrative Performance Measures

Core Strategy 7.1: Improve Emergency Preparedness and Response

- Responsible local, State, and federal agencies with emergency response authority consider the recommendations of the Delta Multi-Hazard Coordination Task Force (Water Code section 12994.5) by January 1, 2014.
- The Department of Water Resources evaluates the potential of creating stored material sites by “over-reinforcing” west Delta levees by January 1, 2014.
- Local levee maintaining agencies consider developing their own emergency action plans, and stockpiling rock and flood fighting materials by January 1, 2014.
- State and local agencies and regulated utilities that own and/or operate infrastructure in the Delta prepare coordinated emergency response plans to protect the infrastructure from long-term outages resulting from failures of the Delta levees by January 1, 2014.

Core Strategy 7.2: Finance and Implement Local Flood Management Activities

- The Legislature creates a Delta Flood Risk Management Assessment District with fee assessment authority.
- The Public Utility Commission (PUC) does the following:
  - Holds hearings on the topic of imposing a reasonable fee for flood and disaster prevention on regulated privately owned utilities with facilities located in the Delta.
  - Directs all regulated public utilities in the PUC’s jurisdiction to immediately take steps to protect the public utilities’ facilities in the Delta from the consequences of catastrophic failure of levees in the Delta.
- The governor issues an executive order directing State agencies with projects or infrastructure in the Delta to set aside funding to pay for flood protection and disaster prevention.

Core Strategy 7.3: Prioritize Flood Management Investment

- The Delta Stewardship Council facilitates development of funding priorities for State investments in Delta levees by January 1, 2015.
- The Delta Stewardship Council develops funding priorities for State investments in Delta levees by January 1, 2015

Core Strategy 7.4: Improve Residential Flood Protection

- 100% of covered actions that involve new residential developments of five or more parcels provide a minimum 200-year level of flood protection when the new developments are located outside specified areas described in the Delta Plan.

Core Strategy 7.5: Protect and Expand Floodways, Floodplains, and Bypasses

- 100% of covered actions that encroach upon a floodway do not significantly impede the free flow of water or jeopardize public safety.
- 100% of covered actions that encroach upon a floodplain do not significantly affect floodplain values and functions, per stated requirements.
- The Department of Water Resources and the Central Valley Flood Protection Board evaluate a bypass and floodways on the San Joaquin River near Paradise Cut.
- Current efforts to maintain navigable waters in the Sacramento River Deep Water Ship Channel and Stockton Deep Water Ship Channel, led by the U.S. Army Corps of Engineers and described in the Delta Dredged Sediment Long-Term Management Strategy (USACE 2007, Appendix G), are continued in a manner that supports the Delta Plan and the coequal goals. Appropriate dredging throughout other areas in the Delta for maintenance purposes, or that would increase flood conveyance and provide potential material for levee maintenance or subsidence reversal is implemented in a manner that supports the Delta Plan and coequal goals.
- The Central Valley Flood Protection Board evaluates whether additional areas both within and upstream of the Delta should be designated as floodways.

Core Strategy 7.6: Integrate Delta Levees and Ecosystem Function

- DWR develops criteria to define locations for future setback levees in the Delta and Delta watershed.

Core Strategy 7.7: Limit State Liability

- The Legislature requires an adequate level of flood insurance for residences, businesses, and industries in flood-prone areas.
- The Legislature considers making changes to State law and/or constitutional changes that address the State’s potential flood liability, including giving State agencies the same level of immunity with regard to flood liability as federal agencies have under federal law.

Chapter 8: Funding Principles to Support the Coequal Goals

Administrative Performance Measures

- An inventory of current State and federal spending on programs and projects that contribute to the coequal goals is conducted.
- A Delta Finance Plan has been developed and is funded.
- State and federal funding gaps have been identified that are determined to hinder progress toward meeting the coequal goals.

Appendix C
Attachment C-4.4
Data Sheets for New and Refined Performance Measures

Performance Measure 4.6: Doubling Goal for Central Valley Chinook Salmon Natural Production

Performance Measure (PM) Component Attributes

Type: Outcome Performance Measure

Description

Increase in Central Valley Chinook salmon population recovery with natural production to reach the state and federal doubling goal.

Expectations

The annual average natural production of Central Valley Chinook salmon runs increases long-term to double the 1967–1991 levels for all runs combined, and for individual run types on select rivers: fall, late-fall, spring, and winter.

Metric

Annual average natural production of all Central Valley Chinook salmon runs and for individual run types on select rivers: fall, late-fall, spring, and winter. Census will be conducted annually for the general population in the Central Valley and select rivers.

Baseline

Set by the Central Valley Project Improvement Act (CVPIA), the baseline is the 1967–1991 Chinook salmon natural production annual average of 497,054 for all Central Valley runs (Figure 1), and for individual run types on select rivers, the baseline values are specified in Table 1.[1]

[1] The baseline values in Table 1 do not add up to the baseline for all runs because not all tributaries are included. The Council will only track individual run types for the select rivers specified in Table 1.

Targets

The 15-year rolling annual average of natural production for all Central Valley Chinook salmon runs increases for the period of 2035–2065, and reaches 990,000 fish by 2065, and for each run on select rivers, the target values are specified in Table 1.[2]

Table 1. Central Valley Chinook Salmon Natural Production Baseline and Target Levels by Run Type and Selected Rivers

Baseline (1967–1991)		Target (2065)	
Sacramento River Watershed	San Joaquin River Watershed	Sacramento River Watershed	San Joaquin River Watershed
Sacramento River mainstem Fall: 115,369 Late-Fall: 33,941 Spring: 29,412 Winter: 54,316	Tuolumne River Fall: 18,949	Sacramento River mainstem Fall: 230,000 Late-Fall: 68,000 Spring: 59,000 Winter: 110,000	Tuolumne River Fall: 38,000
American River Fall: 80,874	Merced River Fall: 9,005	American River Fall: 160,000	Merced River Fall: 18,000
Feather River Fall: 86,028	Stanislaus River Fall: 10,868	Feather River Fall: 170,000	Stanislaus River Fall: 22,000
	Mokelumne River Fall: 4,680		Mokelumne River Fall: 9,300

Basis for Selection

Enacted by the U.S. Congress in 1992, the Central Valley Project Improvement Act (CVPIA) requires improvements to water management to protect fish and wildlife, including achieving the state and federal doubling goal for Central Valley Chinook salmon natural production, relative to 1967–1991 levels. U.S. Fish and Wildlife Service (1995) defines natural production as: “Title 34 defines natural production as: ‘... fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes’ (Section 3403[h]).” Although the CVPIA spurred much action and changes to water management, extensive drought periods have contributed to decreased salmon natural production levels since 1992: the 1992–2015 average was 381,368 compared to the 1967–1991 baseline average of 497,054 (Figure 1) for all Chinook salmon runs. Given the importance of this species for commercial and recreational fishing, and its cultural value, there is considerable interest in tracking its status. Moreover, salmon are a strong indicator species of ecosystem health and of the effectiveness of habitat restoration and water-quality improvement projects because

[2] The targets in Table 1 do not add up to the target for all runs because not all tributaries are included. The Council will only track individual run types for the select rivers specified in Table 1.

these anadromous fish use the vast range of aquatic ecosystems, from headwaters to the ocean (NMFS 2014). Salmon also play an important ecological role during their migration upstream to spawn by transferring nutrients from the ocean to wildlife and vegetation in the Central Valley (Merz and Moyle 2006). They are a critical food resource for terrestrial predators and scavengers, connecting ocean and forest habitats hundreds of miles apart (Wilson et al. 1998). Therefore, declines in the capacity of a watershed to support all stages of salmon can indicate declining ecosystem health (Cummins et al. 2008).

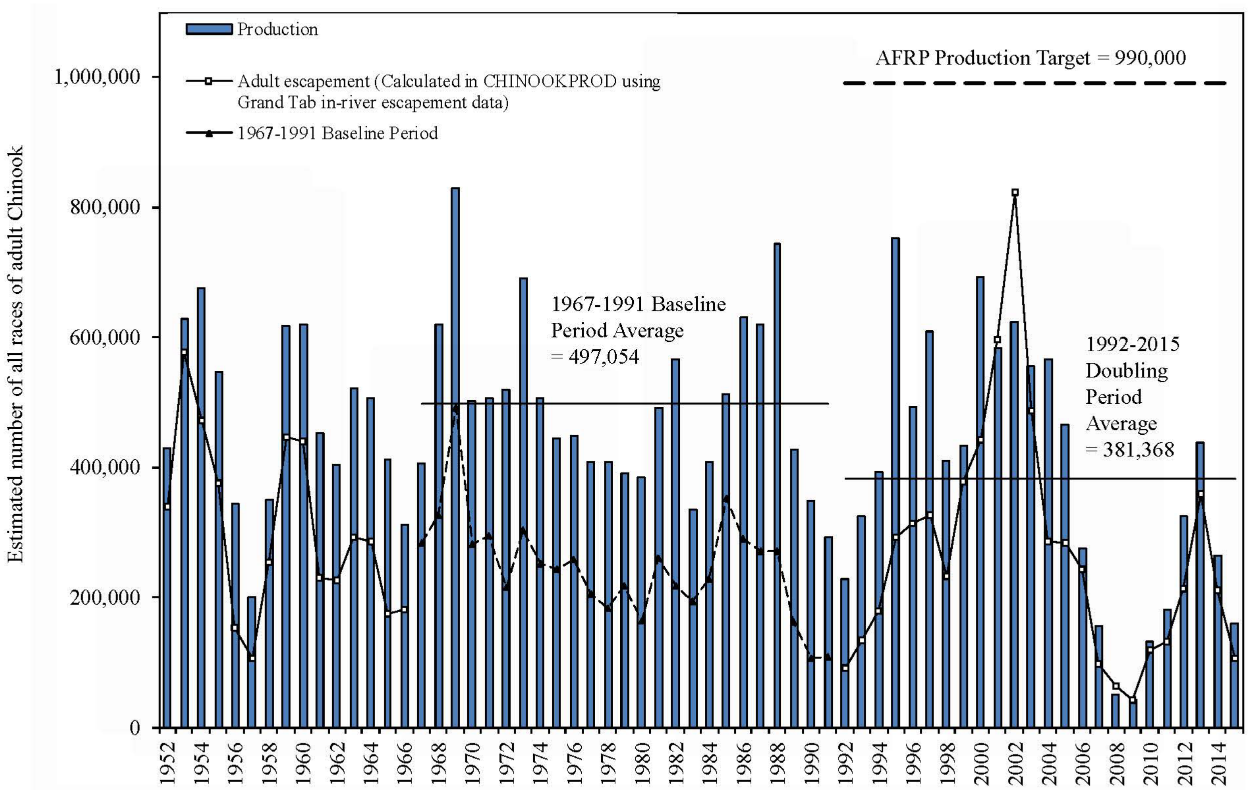

Figure 1. Estimated Yearly Natural Production and In-River Escapement of all Races of Adult Chinook Salmon in the Central Valley Rivers and Streams

This chart illustrates the estimated annual natural production and in-river escapement of all races of adult Chinook salmon in the Central Valley rivers and streams. Chinook salmon escapement is defined as fish that migrate from the ocean to spawn in freshwater streams. The x-axis shows time, starting from 1952 through 2014 in two-year increments. The y-axis shows the estimated number of all races of adult Chinook, ranging from 0 to 1,000,000, in increments of 200,000. Vertical bars represent annual production of all races of Chinook, while a line graph represents the annual adult escapement. The escapement estimates were calculated in ChinookProd using Grand Tab in-river escapement data.

Figure 1. Estimated Yearly Natural Production and In-River Escapement of all Races of Adult Chinook Salmon in the Central Valley Rivers and Streams (contd.)

The chart shows that both production and adult escapement are variable, but that they tend to increase and decrease together. Production and escapement both rose by roughly 200,000 adult Chinook between 1952 and 1953. Production increased the following year, while escapement dropped slightly. Both production and escapement fell in the subsequent three years, to a regional low in 1956 of roughly 200,000 adult Chinook produced and roughly 100,000 escaped. Production and escapement both rose over the next two years, and then varied in concert with one another, peaking in 1969 at more than 800,000 produced and 500,000 escaped. In 1992, production and escapement hit a regional low at less than 250,000 adult Chinook produced and roughly 100,000 escaped. Between 1992 and 2002, both production and escapement generally increased. Production hit a regional peak of more than 750,000 in 1995 and escapement peaked in 2002 at more than 800,000 adult Chinook. Both production and escapement then declined to a low of roughly 50,000 Chinook produced and escaped in 2009. Production and escapement increased between 2009 and 2013 to a regional high of roughly 450,000 produced and 350,000 escaped, then dropped over the next two years.

The central message of the chart is conveyed through comparison of a baseline period average, a doubling period average, and a production target. The chart shows that the 1967–1991 baseline period average equals 497,054 adult Chinook. The chart shows the 1992–2015 doubling period average equals 381,368. The target for the doubling period was 990,000 fish. The chart illustrates that the 1992–2015 average falls well below the target.

Source: USFWS Anadromous Fish Restoration Program 2016

Salmon populations are dependent on a wide variety of factors in the rivers, Delta, and ocean, including suitability of spawning and rearing habitat, predation, and food availability (USFWS and Reclamation 2011). They can be sensitive to changes in water quality, flow, turbidity, and temperature. Moreover, stressors affect various salmon life stages differently (NMFS 2014). Degrading conditions in recent decades have caused major declines in Central Valley Chinook salmon populations, resulting in listing of winter-run Chinook salmon as an endangered species and spring-run Chinook salmon as a threatened species under the federal Endangered Species Act.

Salmon population dynamics are dependent on many factors that occur outside the Delta (e.g., spawning habitat, water temperatures) that can be managed through flow and nonflow management actions such as water operations, fishing regulations, habitat restoration, as well as other factors that cannot be managed (e.g., ocean food-web productivity). Management of water operations, habitat restoration, and increased coordination among agencies in the Delta can help contribute towards the salmon doubling goal (Cummins et al. 2008, Herbold et al. 2018, Dahm et al. 2019). Current ecosystem management seeks to improve the adaptive capacity of salmon in response to climate change by reconnecting and restoring habitats to facilitate ecosystem processes, providing refuge from temperature stress and predation risk, and by increasing food availability (Crozier et al. 2019).

In 2018, the State Water Resources Control Board (SWRCB) charged an Independent Scientific Advisory Panel with developing methods for formulating biological goals for the Bay-Delta Water Quality Control Plan. The Advisory Panel concluded that the baseline for the doubling goal overestimated the natural-origin population (by underestimating hatchery-origin Chinook salmon in total returns) and therefore the doubling goal for natural-origin salmon might also be overestimated (Dahm et al. 2019). Because of the uncertainty in the baseline calculations, an increase in the natural production (positive trend) may provide a better goal, rather than the goal to double the natural production (Dahm et al. 2019). Since 2007, the Constant Fractional Marking program conducted by CDFW has helped increase the accuracy of fall-run natural production estimates. Therefore, in addition to the main doubling goal target, there will be two submetrics that address the limitations of the current datasets and compliments the overall intentions of the doubling goal.

These submetrics are: 1) an increase in natural-origin population as a positive slope of the 15-year rolling annual average for the period of 2035–2065; 2) a positive slope of the 15-year rolling annual average of natural production using CFM data from 2010–2065. These values will be calculated for each tributary and Chinook run listed in the targets section (above).

Linkages to Delta Reform Act and the Coequal Goals

Delta Reform Act

Achieving the target of positive slope in the 15-year annual average of natural production for all Chinook salmon is a measure of “Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations” (Water Code section 85802(c)(5)).

This performance measure works together with other performance measures—Fish Migration Barriers (PM 4.13), Increase Seasonal Inundation (PM 4.15), Acres of Natural Communities Restored (PM 4.16), and Subsidence Reversal for Tidal Reconnection (PM 4.12)—to assess the status and trends in “the health of the Delta’s estuary and wetland ecosystem for supporting viable populations of Delta fisheries and other aquatic organisms” (Water Code section 85211(a)).

Delta Plan Core Strategy

4.4 Protect Native Species and Reduce Impact of Nonnative Invasive Species.

Methods

Baseline Methods

The baseline is the average number of annual natural production of all Central Valley Chinook from 1967–1991 which is 497,054 fishes. This was set by the Central Valley Project Improvement Act (CVPIA) of Public Law 102-575, passed by Congress in 1992.

Target Methods

The target is doubling the baseline to 990,000 by 2065, expressed as the 15-year rolling annual average of natural production for all Chinook salmon runs. The 15-year rolling average represents the time frame for about five salmon generations and is intended to account for short-term variability of salmon production.

Data Sources

Primary Data Sources

The primary data sources listed below will be used for tracking this performance measure:

1. U.S. Fish and Wildlife Service (USFWS) ChinookProd. Assesses progress toward the CVPIA doubling goal for natural production. These data are based upon California Department of Fish and Wildlife (CDFW) Grand Tab data. Estimates of adult salmon are based on counts entering hatcheries and migrating past dams, carcass surveys, live fish counts, and ground and aerial redd counts.
    a. Content: ChinookProd is a spreadsheet database maintained by the USFWS Anadromous Fish Restoration Program, which calculates natural production of each salmon run along with the combined value of all runs (Figure 1). ChinookProd is both a data source and an analytical tool.
    b. Update frequency: Updated annually.
2. CDFW Grand Tab. Provides estimates of adult salmon escapement (returning spawners) for different run types and watersheds. Estimates are provided by the CDFW; USFWS; California Department of Water Resources; East Bay Municipal Utilities District, U.S. Department of the Interior, Bureau of Reclamation (Reclamation); Lower Yuba River Management Team; and Fisheries Foundation of California. Grand Tab does not characterize whether fish are wild or hatchery origin, just whether the adults are spawning in-river (natural) or in-hatchery.

Escapement data and visualizations are available through the Central Valley Prediction and Assessment of Salmon website (SacPAS).

a. Content: Tabular reports of salmon escapements by salmon run and rivers.

b. Update frequency: Updated annually.

Alternative Data Sources

Alternative data sources will be used if the primary data sources become unavailable or insufficient. Alternative data sources may be used concurrently with the primary data sources depending on best available science and the availability of the primary source.

1. CDFW Constant Fractional Marking.https://www.fws.gov/cno/fisheries/CAMP/Documents-Reports/CDFW Constant Fractional Marking. Until 2007, only experimental releases of hatchery fall-run Chinook salmon were marked and tagged, resulting in lack of data on hatchery impacts on natural production. Since 2007, the constant fractional marking (CFM) program coded-wire tagging and adipose fin-clipping of at least 25 percent of all CV hatchery Chinook salmon. Each CWT contains a binary or alpha-numeric code that identifies a specific release group of salmon (e.g., agency, species, run, brood year, hatchery or wild stock, release size, release date(s), release location(s), number tagged and untagged). CFM provides a more accurate estimate of the relative contribution of hatchery fish to total natural production.
   a. Content: Tabular reports of salmon escapements by salmon run and rivers.
   b. Update frequency: Updated annually
2. USFWS Comprehensive Assessment and Monitoring Program Annual Report. USFWS Comprehensive Assessment and Monitoring Program Annual Report.
   a. Content: Annual report that provides updates on progress of the Anadromous Fish Restoration Program and the salmon doubling goal.
   b. Update frequency: Updated annually.

Process

Data Collection and Analysis

Every year, Council staff will update the status of this performance measure by:

a. Downloading data from primary data source #1 every October 1. Council staff will contact the data owner, USFWS, for quality assurance-quality control questions, if necessary.

b. Calculating the 15-year rolling annual average of natural production for all Chinook salmon runs.

c. Calculating the slope (linear regression) of 15-year rolling annual averages of natural production for all Chinook salmon runs.

d. Displaying results such as bar graphs (e.g., Figure 1) showing the rolling annual natural production of all salmon runs and the status, compared to the baseline. The 15-year rolling averages will be plotted against year and a slope will be calculated to measure if the salmon population is growing (positive slope).

Interim Performance Assessment

In order to provide a short-term assessment of progress toward the doubling target, and to address limitations of the current datasets, interim milestones are set using two submetrics:

1. Positive slope of the 15-year rolling annual average of Central Valley Chinook salmon natural production, calculated and evaluated annually. The interim milestone is a positive slope of the 15-year rolling annual average to be achieved by 2035.
2. Positive slope of the 15-year rolling annual average of natural production using the Constant Fractional Marking (CFM) data which is available from 2010 onwards. The interim milestone is a positive slope of the 15-year rolling annual average by 2035.

Annually, the linear regression and associated slope for the regression line will be calculated and compared to the baseline and to the previous year values. The 15-year rolling average was chosen to represent five Chinook salmon generations to provide long enough trends to conclude whether populations are in recovery or not (USFWS 1995).

The interim metrics are calculated by each run and by selected rivers where production data is available. Interpretation of short-term performance milestones assessments will include consideration of external factors beyond management control (e.g., ocean and climate conditions) and the relative importance of the Delta as the migration corridor and rearing habitat within the salmon life cycle.

Process Risks and Uncertainties

Current monitoring efforts do not adequately characterize whether fish are wild or of hatchery-origin. Consistently and comprehensively estimating the contribution of hatchery-origin salmonids in the catch and spawning grounds is the greatest deterrent to reasonably accurate production estimates of natural-origin salmonids (Dahm et al. 2019).

The USFWS ChinookProd estimates of annual natural production of each Chinook salmon run from each watershed includes four components:

1. In-river spawner abundance (i.e., escapement): In-river spawner abundance is based on the CDFW Grand Tab report. If there is a salmon hatchery in a watershed, hatchery returns are quantified by counting the number of salmon that enter those fish hatcheries. In-river harvest is estimated using best professional judgment based on CDFW angler harvest surveys.
2. Hatchery returns.
3. In-river harvest by anglers.
4. Ocean harvest is based on reporting by the Pacific Fishery Management Council.

Climate change poses another uncertainty to reaching salmon doubling targets. To help address this, Council staff will work with SWRCB and other agencies to track abundance as well as density-dependence survival rates, distribution, diversity, and life stage survival rates of Central Valley salmon in order to better adaptively manage their populations. Moreover, there is a need to investigate how these population parameters are affected by management actions.

Reporting

Every year, Council staff will report the status of this performance measure by:

1. Posting updates on the Performance Measures Dashboard.
2. Providing results in the Council’s annual report (published in January).
3. Communicating management-relevant results at Council and Delta Plan Interagency Implementation Committee (DPIIC) public meetings.
4. Presenting findings at technical interagency groups, professional gatherings, and conferences.

Every five years, Council staff will assess and report the status of this performance measure by:

1. Communicating findings in the five-year review of the Delta Plan.
2. Informing the Council’s adaptive management process, and other decision-making.

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Performance Measure 4.12: Subsidence Reversal for Tidal Reconnection

Performance Measure (PM) Component Attributes

Type: Output Performance Measure

Description

Subsidence reversal[1] activities are located at shallow subtidal elevations to prevent net loss of future opportunities to restore intertidal wetlands through tidal reconnection in the Delta and Suisun Marsh.

Expectations

Preventing long-term net loss of land at intertidal elevations in the Delta and Suisun Marsh from impacts of sea level rise and land subsidence.

Metric

1. Acres of Delta and Suisun Marsh land with subsidence reversal activity located on islands with large areas at shallow subtidal elevations. This metric will be reported annually.
2. Average elevation accretion at each project site presented in centimeters per year. This metric will be reported every five years. Tracking will continue until a project is tidally reconnected.

Baseline

1. In 2019, zero acres of subsidence reversal on islands with large areas at shallow subtidal elevations.
2. Soils in the Delta are subsiding at a rate of between 0 cm/year and 1.8 cm/year.

[1] Subsidence reversal is a process that halts soil oxidation and accumulates new soil material in order to increase land elevations. Examples of subsidence reversal activities are rice cultivation, managed wetlands, and tidal marsh restoration.

Target

1. By 2030, 3,500 acres in the Delta and 3,000 acres in Suisun Marsh with subsidence reversal activities on islands with at least 50 percent of the area or at least 1,235 acres at shallow subtidal elevations.
2. For each project, an average elevation accretion of at least 4 centimeters per year until the project is tidally reconnected.

Basis for Selection

General Purpose

California will experience sea level rise over the next century. The Ocean Protection Council's guidance estimates that sea level rise at San Francisco Bay, the nearest forecasted area to the Delta, could range from an increase of 1.6 feet to 10.2 feet by 2100 (OPC 2018). Anticipated sea level rise will increase pressure on already stressed Delta ecosystems (Council 2018). In addition to sea level rise, most of the land in the Delta is subsiding due to microbial oxidation and areas in the central Delta are already below sea level (Deverel et al. 2016). The areas at subtidal elevations offer limited ecological value if reconnected to a stream because species native to the Delta are not well adapted to lake-like deep water habitats (Durand 2017). Only a thin band of land is at appropriate elevations suitable for tidal restoration through hydrologic reconnection (Delta Plan, Appendix Q2) and that band is getting smaller as the landscape subsides and sea level rises. Hence, the potential for future tidal restoration is being lost.

Many of the existing areas suitable for tidal wetland restoration are already being targeted for restoration as part of the California EcoRestore initiative.[2] Finding additional areas suitable for tidal wetland restoration will become increasingly difficult. Many of the most suitable areas already have tidal wetland restoration projects planned, and other areas in the Delta are becoming incapable of supporting intertidal restoration due to sea level rise and subsidence. One way to preserve the potential for future intertidal restoration on the landscape is through subsidence reversal.

If subsidence reversal activities are located at suitable locations, the accumulated land can counteract effects of sea level rise and historic subsidence, and maintain or increase land elevation. Recovering lost land will also preserve the opportunities for tidal reconnection. Subsidence reversal activities in locations with current shallow subtidal elevations could recover land for tidal restoration and prevent further losses

[2] California EcoRestore is a California Natural Resources Agency initiative (http://resources.ca.gov/ecorestore).

from sea level rise. To recover tidal restoration opportunities, islands identified in this performance measure should initiate subsidence reversal projects by at least 2030, and then continue long-term until the land reaches the desired intertidal elevation—becoming available for tidal reconnection and subsequent tidal wetland restoration.

The Council's landscape model (see Methods section below) indicates that from 2008 to 2019 (the decade following the passage of the Delta Reform Act of 2009), the Delta and Suisun Marsh lost 3,500 acres and 3,000 acres of land, respectively, at intertidal elevations due to subsidence and sea level rise. By initiating subsidence reversal activities on 3,500 Delta acres and 3,000 acres in Suisun Marsh, land that was once at intertidal elevations can be recovered, and subsequently, maintaining opportunities for future tidal reconnection and restoration. In order to accrete sufficient elevation at the identified locations, projects would need to accrete at least 4 centimeters per year.

Subsidence reversal is a process that increases land elevation by halting soil oxidation and accumulating new soil material. Subsidence reversal activities are conservation actions that can be implemented as multibenefit projects that support native species and natural communities. Subsidence reversal projects that are managed wetlands can provide habitat for migratory bird species (Shuford and Dybala 2017, Shuford et al. 2019) and support native vegetation communities. After suitable land elevation is reached, locations can become available for tidal reconnection and tidal wetland restoration that in turn benefits aquatic species and native fish populations, while restoring natural geomorphic processes.

Relationship to the Subsidence Reversal and Carbon Sequestration Performance Measure (PM 5.2)

Delta Plan performance measure PM 5.2, "Subsidence Reversal and Carbon Sequestration," tracks carbon sequestration projects and acres of subsidence reversal projects across the entire Delta and Suisun Marsh. PM 5.2 has a target of 30,000 acres of subsidence reversal and carbon sequestration in the Delta to be achieved by 2030. Managed wetlands or rice production on deeply subsided areas operated for subsidence reversal sequester carbon in the organic material they accrete. This decreases carbon emissions for organic soils. Subsidence reversal projects to sequester carbon can take advantage of carbon credit markets while also helping California meet its greenhouse gas reduction targets. Shallow subsided areas (shallow subtidal elevations) tend to not emit high amounts of carbon dioxide compared to the deeply subsided areas, therefore, it is unlikely that carbon markets will incentivize projects in these areas.

This performance measure PM 4.12, "Subsidence Reversal for Tidal Reconnection" is different from PM 5.2 because it only tracks subsidence reversal located on islands with shallow subtidal elevations, whereas PM 5.2 tracks both shallow and deeply subsided areas. Shallow subtidal elevations have a reasonable chance of achieving intertidal elevations through subsidence reversal in the timeframe from 2020 to about 2100, preventing the net loss of future opportunities to restore tidal wetlands. Deeply subsided areas may need more than 80 years to be restored to intertidal elevations making such projects unlikely to result in intertidal habitat within a planning horizon of 2100.

Relationship to the Performance Measure Acres of Natural Communities Restored Performance Measure (PM 4.16)

The performance measure PM 4.16, "Acres of Natural Communities Restored Performance Measure" targets the creation of 32,500 acres of tidal wetlands. Actions that support the landscape potential for tidal wetland restoration will also support the achievement of that target. If the target is achieved, this performance measure would result in 6,500 acres of wetlands tidally reconnected to the system in Suisun Marsh and the Delta. The 6,500 acres suitable for tidal restoration that would result from successful achievement of this performance measure (PM 4.12) target would account for 20 percent of the PM 4.16 target acreage. However, depending on the location and subsidence rates, some of the acreage tracked by this performance measure may not be suitable for reconnection by the 2050 target of PM 4.16.

Linkages to Delta Reform Act and the Coequal Goals

Delta Reform Act

The loss of land elevation is a major stressor on the ecosystem that makes restoration of the Delta more difficult. The Sacramento-San Joaquin Delta Reform Act of 2009 (Delta Reform Act) defines a number of strategies for restoring a healthy Delta ecosystem. Achieving the target in this performance measure would support the following subgoals and strategies for restoring a healthy ecosystem:

- **"Restore large areas of interconnected habitats within the Delta and its watershed by 2100." (Water Code section 85302(e)(1)).** Due to sea level rise and subsidence on land at current intertidal elevation, the potential for habitat reconnection is being lost. In the 10-year period (2009 to 2019) of modeled elevation change (see methods section below), 3,500 acres are estimated to have been lost in the Delta and 3,000 acres in Suisun Marsh since the passage of the Delta Reform Act. Applying subsidence reversal activities on the same amount of land will prevent the net loss of opportunities to restore tidal wetlands due to subsidence and sea level rise.

- **"Restore Delta flows and channels to support a healthy estuary and other ecosystems." (Water Code section 85302(e)(4)).** Delta geometry has been radically simplified from the complex channel systems that were common in the pre-reclamation Delta (SFEI-ASC 2016). With large-scale wetland restoration, the formation of complex dendritic channels is possible. This measure tracks projects that could create new spaces for restoring those geomorphic formations. Those new spaces would offset the loss of elevation occurring elsewhere.
- **"Restore habitat necessary to avoid a net loss of migratory bird habitat and, where feasible, increase migratory bird habitat to promote viable populations of migratory birds."** (Water Code § 85302(e)(6)). Both managed wetlands—for subsidence reversal in deeply subsided and shallow subsided areas—provide habitat for migratory bird species (Shuford and Dybala 2017, Shuford et al. 2019).

In addition to providing subgoals and strategies for restoring a healthy Delta ecosystem, the Delta Reform Act also mandates that the Delta Plan include measures that promote specified characteristics of a healthy Delta ecosystem (Water Code section 85302(c)). Achieving the target in this performance measure would promote the following characteristics of a healthy Delta, as identified in the Delta Reform Act:

- **"Viable populations of native resident and migratory species." (Water Code section 85302(c)(1)).** Prior to reclamation, native and migratory species thrived in a dynamically inundated tidal marsh system (SFEI-ASC 2016). In the last 150 years, more than 95 percent of wetlands in the Delta have been lost; those wetlands were habitat for many native species (SFEI-ASC 2016). Without opportunities on the landscape to restore lost tidal wetlands, it will be difficult to support viable populations of native resident and migratory species. PM 4.16, "Natural Communities Restored," sets targets for the number of acres of natural wetlands to be restored. Achieving that goal will require significant space on the landscape. Meeting the target of this measure will ensure that the Delta landscape maintains opportunities for natural wetland restoration, as opposed to losing suitable landscapes due to sea level rise and subsidence.
- **"Diverse and biologically appropriate habitats and ecosystem processes." (Water Code section 85302(c)(3)).** The pre-reclamation Delta was characterized by a diverse series of seasonally inundated tidal wetlands that provided complex and variable hydrology and landscape patterns (SFEI-ASC 2016). Restoring these processes will require space on the landscape that is not deeply subtidal. The intertidal space is being lost to subsidence and sea level rise. Meeting the target of this measure will ensure that the Delta landscape recovers opportunities to restore seasonally inundated tidal wetlands and fluvial and geomorphic patterns.

- **"Reduced threats and stresses on the Delta ecosystem." (Water Code section 85302(c)(4)).** Land loss is a stress on the ecosystem. Deeply subsided islands offer less potential habitat value than those of intertidal elevations (Durand 2017). Meeting the target of this measure will ensure no net loss of the land at intertidal elevation.
- **"Conditions conducive to meeting or exceeding the goals in existing species recovery plans, and state and federal goals with respect to doubling salmon populations."** (Water Code section 85302(c)(5)). Loss of land at intertidal elevations prohibits opportunities for restoring large areas of tidally connected wetlands that support native fish species and the doubling of salmon populations. Meeting the target of this measure will ensure that the Delta landscape maintains opportunities for natural wetland restoration.

Delta Plan Core Strategy

4.3 Protect Land for Restoration and Safeguard Against Land Loss.

Methods

Subsidence Reversal Activity

This performance measure tracks "subsidence reversal activity." Subsidence reversal is a process that both halts subsidence caused by organic soil oxidation and leads to increases in land elevation through accumulation of new soil material. Subsidence reversal results in land elevations that are higher than land elevations prior to subsidence reversal; the process does not necessarily result in land elevations at or above mean sea level, however, because this depends on the initial elevation and the rate of subsidence reversal over time. Examples of subsidence reversal management actions include, but are not limited to, increasing land elevation by accreting organic material in managed wetlands, and placement of fill and levee breaching to reestablish hydrological connection with a river or bay.

For the purposes of this performance measure, subsidence reversal activity is defined as projects that include landscape interventions that increased land elevation in nontidally connected locations whose elevations are below nearby water levels. There are two common forms of subsidence reversal in the Delta. The first form is vegetation-based, in which managed wetlands (Miller et al. 2008), or a rice and wetland mosaic landscape (Deverel et al. 2017) are used to accrete organic material on an area that increases elevation. The other form of subsidence reversal is through the application of sediment on a landscape. For example, prior to tidal reconnection elevations in areas of the Montezuma Wetlands had dredge material deposited on them to raise their elevations. Due to limited availability of dredge spoils and other sediment, this form of subsidence reversal is likely to be less common and more limited in its geographic scope.

Baseline Methods

Islands in the Delta and Suisun Marsh with large enough areas at shallow subtidal elevations were identified as capable of reaching intertidal elevations with subsidence reversal ongoing from 2030 to 2100 (see method below).

The subsidence rates for soils in the Delta of between 0 cm/year and 1.8 cm/year are based on soil composition models from subsidence rates (Deverel et al. 2016).

Target Methods

Acres of Intertidal Land Lost Since the Delta Reform Act

Areas at current intertidal elevation were derived from the Delta and Suisun Marsh 2007-2008 digital elevation model (DEM) and 2017 DEM revisions by the Department of Water Resources (DWR) (Tolentino 2017). Because the DEM was produced based on (mostly) conditions on the ground in 2008 (Tolentino 2017), the baseline is 2008 and the analysis tracks intertidal elevation loss of the following ten years. The estimated intertidal land loss is calculated for 10 years of elevation change based on the projected subsidence and sea level rise (method described in Appendix 1). The resulting 3,500 Delta acres and 3,000 acres in Suisun Marsh is the estimated area of land lost following the passage of the Delta Reform Act.

The land loss is calculated for ten years based on the Tolentino (2017) DEM, most of which is based on 2008 LiDAR survey, because at the time of development of the model it was the best available data. Projected sea level rise and subsidence indicate that more intertidal land could be lost if action is not taken.

Implementation by 2030

The target date for project implementation is for 2030 because rates of sea level rise and subsidence reversal have a high uncertainty. A longer-term target date requires more foreknowledge of sea level rise and the future development of subsidence reversal technology. Subsidence reversal technology in the Delta is in the early stages of development. Currently, there are only a few subsidence reversal projects in the Delta and none in Suisun Marsh. By 2030, more subsidence reversal projects are expected to be implemented and evaluated, contributing to the state of the science and the adaptive management. The 2030 target date is consistent with the existing performance measure PM 5.2, “Subsidence Reversal and Carbon Sequestration.”

Identifying Islands with Large Areas of Land Capable of Reaching Intertidal Elevations Suitable for Potential Future Restoration by 2100

The Delta and Suisun Marsh islands were analyzed by Council staff to determine which islands contain significant opportunities to achieve intertidal elevations (needed for tidal reconnection and tidal wetland restoration) through soil accretion from subsidence reversal (technical details are described in Appendix 1). For each island in the Delta and Suisun Marsh, Council staff estimated the amount of vertical soil accretion that could potentially be gained through subsidence reversal based on empirical data from existing subsidence reversal projects. Staff then used GIS to count, for each island, the number of acres that could reach intertidal elevations by 2100 or sooner.

Staff reviewed the elevations at each island and included any island with at least 50 percent of its area or at least 1,235 acres at current shallow subtidal elevations as being able to reach intertidal elevations by 2100 with subsidence reversal and therefore provide future opportunities for tidal reconnection. The 1,235-acre threshold was selected because it is the minimum area needed for complex intertidal channel systems to develop in a wetland complex (SFEI-ASC 2016) and would therefore allow for large-scale intertidal wetland restoration. This 1,235-acre threshold is also used in Delta Plan, Appendix Q2 to determine if a tidal wetland project is large-scale. An island list (Appendix 2) and map (Figure 1) were manually corrected to exclude islands that included large acreage but little connectivity to support channel formation such as Brannan-Andrus Island.

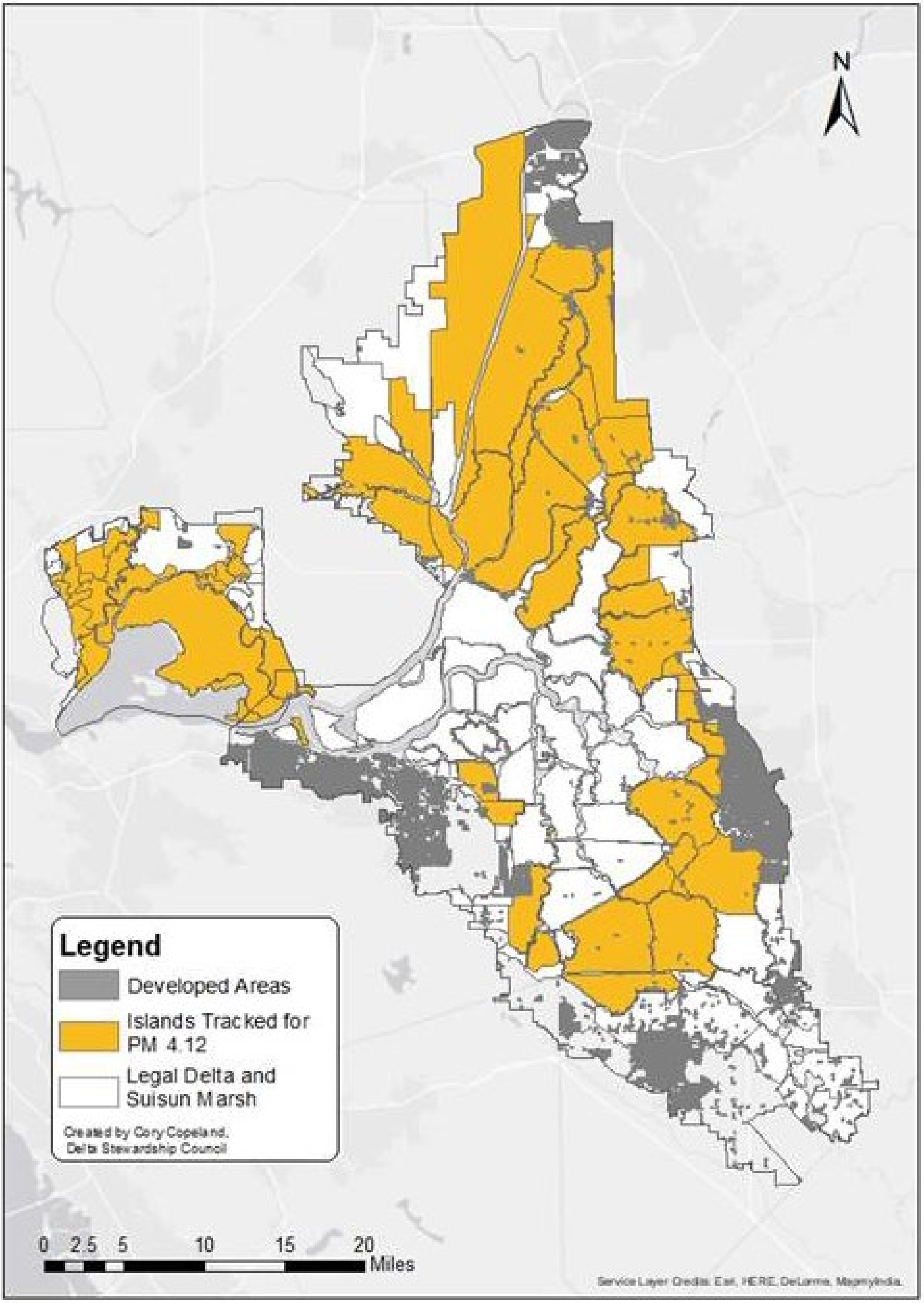

Figure 1. Islands Tracked in this Performance Measure

Figure 1. Islands Tracked in this Performance Measure (contd.)

This map shows the areas where subsidence reversal activities ongoing through 2100 can produce intertidal elevations on or before 2100.

Islands that are tracked for this performance measure are concentrated in Suisun Marsh, Cache Slough, Yolo Bypass, the north Delta along the Sacramento River, the eastern Delta near the Cosumnes/Mokelumne confluence, adjacent to the City of Stockton, and in the south Delta north of Tracy and Lathrop. Islands that are not tracked for this performance measure are concentrated in the central Delta where land is too deeply subsided to be reconnected to tidal inundation; and at the edges of the Delta and Suisun Marsh, where land is above the tidal range. The names of the individual islands that are tracked for this performance measure are listed in Appendix 2 of this document.

Alternative formats of this map are available upon request.

Accretion Metric and Target Selection

This measure identifies that projects would need to accrete at least 4 centimeters per year (cm/yr) over a long-term project life. The rate of 4 cm/yr has been shown to be possible over the short-term in the Delta based on empirical data from Twitchell Island (Miller et al. 2008). Subsidence reversal activities must continue to accrete elevation at an average 4 cm/yr rate to reach intertidal elevations suitable for tidal reconnection and tidal wetland by 2100.

Data Sources

Primary Data Sources

The listed primary data sources below will be used for tracking this performance measure. If subsidence reversal project-implementers choose to report project information outside of these listed sources, Council staff will seek to identify additional sources of project information.

1. The Delta Stewardship Council Covered Actions website. Subsidence reversal projects are likely to meet the definition of a covered action and will need to establish consistency with the Delta Plan before implementation.
    a. Content: Covered actions project description provides details about types of subsidence reversal activities, acreages, and locations.
    b. Update frequency: As covered actions are submitted.
2. San Francisco Estuary Institute (SFEI) Project Tracker. The SFEI project tracker is a tool that supports regional tracking of restoration projects. Restoration

projects, including subsidence reversal projects created for the purpose of future intertidal reconnection are anticipated to be tracked on Project Tracker.

   a. Content: Project monitoring region wide.
   b. Update frequency: As projects are implemented.

3. DWR. This agency has the lead role in implementing subsidence reversal projects through the West Delta Program. Initially data will be collected by DWR until other organizations, landowners, and stakeholders begin implementing subsidence reversal projects.
   a. Content: Project specific information.
   b. Update frequency: On a project-by-project basis.
4. CA Wetland Protocol Group. Consists of multiple organizations and/or agencies (e.g., Sacramento-San Joaquin Delta Conservancy (Delta Conservancy), California Department of Fish and Wildlife (CDFW), Sacramento Municipal Utilities District (SMUD), Metropolitan Water District of Southern California (MWD), and the California Coastal Conservancy).
   a. Content: Project specific information.
   b. Update frequency: Variable.
5. California Department of Fish and Wildlife Wetlands Restoration for Greenhouse Gas Reduction Program. Uses Cap-and-Trade money to fund greenhouse gas reduction of emissions. Delta wetlands are a potential future target for this program.
   a. Content: Project specific information.
   b. Update frequency: Based on funding cycles, usually annual or shorter.
6. AmeriFlux Network. U.S. Department of Energy initiative. A network of monitoring stations measuring ecosystem CO2, water, and energy fluxes in North, Central, and South America. For example, the Twitchell Wetland (Twitchell Island East End Habitat Restoration Project) project has a page that includes project-related publications.
   a. Content: Project and related research information.
   b. Update frequency: Variable.
7. San Francisco Bay and Sacramento-San Joaquin Delta Digital Elevation Model (DEM). U.S. Geological Survey DEM is developed based on synthesizing LiDAR, single- and multi-beam sonar soundings, and existing integrated maps collated from multiple sources. It is possible to calculate site-specific changes in land elevation from revisions and updates to DEM.

   a. Content: Elevation data.

   b. Update frequency: About every 10 years.

Alternative Data Sources

Alternative data sources will be used if the primary data sources become unavailable or are insufficient. Alternative data sources can be used concurrently with the primary data sources as a reference or as supplemental information. For this performance measure, the alternative data sources focus on subsidence reversal project implementation that could technically occur independent of the state interests described above, but it is not likely.

1. University of California research programs. UC Berkeley monitors greenhouse gas fluxes on rice and wetlands, and establishes baselines for typical farming practices. UC Davis is researching carbon stock, agronomy effects, and economics of rice management for carbon sequestration.
   a. Content: Research results and published references.
   b. Update frequency: Variable.

Process

Data Collection and Assessment

Every year, Council staff will update the status of this performance measure by:

1. Reviewing the listed primary data sources, and if necessary, contacting the responsible agencies for clarifications on project status.
2. Compiling relevant data and comparing for changes from previous years.
3. Reviewing locations of subsidence reversal projects to assess if they are located on islands listed in this measure (Figure 1 and Appendix 2). Projects on other islands not included in this metric, may be reported under PM 5.2 “Subsidence Reversal and Carbon Sequestration.”
4. Calculating annual acreage of subsidence reversal projects showing a comparison over time and gathering information about vertical elevation changes if available.
5. Displaying project locations on a map.

6. Disclosing alternative or additional data sources used by including them on the Performance Measures Dashboard.

Every five years, Council staff will update the status of this performance measure by:

- Reviewing subsidence reversal project publications, reports, and presentations related to project performance for site-specific accretion rates. Vertical land accretion rates will be reported as a long-term average.
- Reviewing projects to determine if they reached intertidal elevations and have become tidally connected. Once that occurs, staff will no longer track vertical accretion in that project.

Process Risks and Uncertainties

The four major risks related to this measure are the dependence on Delta levees, the sustainability of accretion rates, rates of sea level rise, and timely and comprehensive project reporting. As a part of the Council's adaptive management process, staff will regularly review uncertainties related to the amount of sea level rise, effects of sea level rise, rates of subsidence, subsidence reversal rates, elevations, and project implementation (Table 1).

Delta Levees

Projects below water elevation are dependent on the ongoing maintenance of levees. If a subsided island were to experience levee failures prior to achieving intertidal elevations, and the island was not recovered, it would likely add limited ecological value to native species in the system (Durand 2017). Many islands that may be targets for subsidence reversal are at risk of levee failure (Bates and Lund 2013). While subsidence reversal would decrease the likelihood of levee failures, this remains a persistent risk in the system for subsidence reversal.

Sustainability of Accretion Rates

The identified target of 4 cm/yr of newly accreted elevations is based on a historical statistic. On Twitchell Island, early results for a subsidence reversal project showed that 4 cm/yr was possible (Miller et al. 2008). However, the authors of that report, and subsequent research, indicates that newly accreted organic soils are less dense, and as more soil accretes, the soils compress. This indicates that a long-term accretion rate of 4 cm/yr is unlikely without management adjustments that increase accretion rates; therefore, such adjustments are being explored. Metal-based coagulants sometimes used in wastewater treatment are being explored as a method for capturing more organic material as soil. Early results from a research project in the Delta indicate that applying polyaluminum chloride could increase short-term accretion rates to 6 cm/yr

(Stumpner et al. 2018). The study, however, notes that these new soils are less dense, and may be subject to greater compression, making 6 cm/yr an unlikely long-term vertical accretion rate.

Sea Level Rise

Sea level rise forecasting carries significant uncertainty. The range of sea level rise at San Francisco Bay—recommended for planners to consider by the Ocean Protection Commission—is between 0.49 meters (1.6 feet) and 3.1 meters (10.2 feet) through 2100 (OPC 2018, p. 18). For the landscape model, the median sea level rise projection of 0.76 meters (2.5 feet) was chosen for the high-emission scenario. The Delta, and especially the eastern parts of the Delta where the least-subsided islands are located, is inland from the San Francisco Bay; therefore, likely impacts from sea level rise in the Delta will be experienced at a lower rate. If sea level rise occurs more slowly than the median projection, and affects these areas less than projected, this analysis may have ultimately excluded locations capable of reaching intertidal elevation through subsidence reversal. However, if sea level rise occurs more quickly than projections indicate, the analysis may have included areas unlikely to achieve intertidal elevations given the assumptions of the model.

This uncertainty is managed two ways. The first way is by aggregating the subisland scale analysis of appropriate locations to the island scale. A more rapid rate of sea level rise may lead to a lesser portion of the island reaching intertidal elevations, but unless there is rapid sea level rise much of the island may still be suitable for future intertidal reconnection. The second way this uncertainty is managed is by offering a short-term target with an acreage capable of being accomplished by means of projects.

Project Reporting

For this performance measure, there is no single data source. Instead, tracking these metrics will require Council staff to stay aware of projects implemented in the Delta. These sources will be tracked at least annually on a recurring basis but may be updated more frequently as Council staff become aware of projects. Subsidence reversal projects implemented by a state or local agency in the Delta are likely to be subject to Council's process for potential covered actions to determine consistency with the Delta Plan. However, Council staff will review the identified sources for information on projects.

Reporting

Every year, Council staff will report the status of this performance measure by:

1. Posting updates on the Performance Measures Dashboard.

2. Providing results in Council's annual report (published in January).
3. Communicating management-relevant results at Council and Delta Plan Interagency Implementation Committee (DPIIC) public meetings.
4. Presenting findings at technical interagency groups, professional gatherings, and conferences.

Every five years, Council staff will assess and report the status of this performance measure by:

1. Communicating findings in the five-year review of the Delta Plan.
2. Informing the Council's adaptive management process and other decision-making.
3. Council staff will evaluate six key uncertainties (shown in Table 1) related to the amount of anticipated sea level rise, the heterogeneity of its effects, and the rates of subsidence in the Delta to determine the trigger for reassessment of targets or metrics for this performance measure.

Table 1. Key Uncertainties for Effectiveness Assessment Review

Key Uncertainty	Assumption Made	Trigger for Reassessment
Amount of sea level rise	2.5 feet of sea level rise	Sea level rise occurs faster or slower than projected
Effects of sea level rise	Uniform effects	Improved information on spatially heterogeneous effects of sea level rise in the Delta and Suisun Marsh
Rates of subsidence	Rates occur based on soil composition consistently over time	Improved models or empirical subsidence data that significantly improves estimates
Subsidence reversal rates	4 centimeters per year	Rates change due to site-specific characteristics or new management technologies.
Elevations	Elevations from Tolentino 2017 DEM	Significant change in understanding of Delta landscape elevations.
Project implementation	Projects implemented soon after the adoption of the ecosystem amendment.	If projects are planned but not implemented soon after the adoption of the ecosystem amendment, the appropriate areas may need to be re-evaluated for new implementation scenarios.

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Appendix 1: Detailed Methods

Past Elevation Change Formula

The formula below is the set of intertidal elevations that meet the condition of being within the difference between current intertidal elevation and intertidal elevation 10 years from now (see Figure 1 for an illustrated explanation of the methods). These methods are applied to a 200 m-cell size raster grid covering the Delta and Suisun Marsh.

IT = (IT1 U IT10) - IT10

The acreage area of ***IT*** is an estimate of the number of acres at intertidal elevations today that will not be intertidal after 10 years.

The intertidal zone for the first year (IT_1) is defined using the following formula:

IT1 = MHHW > E < MLLW

Where ***E*** is elevation based on the Delta and Suisun Marsh DEM (Tolentino 2017) which was aggregated to $200m^2$. The DEM was aggregated due to computational limitation. Running the landscape model for multiple scenarios on the aggregated DEM required large live memory resources that dramatically slowed the processing. The aggregation to $200m^2$ improved processing. It was determined that local conditions at a smaller scale likely would better suited for a site specific analysis conducted by a project proponent rather than a landscape level analysis. The aggregation level of $200m^2$ was chosen because it is discrete enough to be smaller than any reasonable project, but large enough ease any computational bottlenecks.

MLLW is tidal datum for mean lower low water levels.

MHHW is tidal datum for mean higher high water levels.

The intertidal zone (IT_{10}) for the tenth year is defined using the following formula:

IT10 = MHHW > E-∆SLR+∆ES > MLLW

ΔSLR is the expected sea level rise. This analysis assumes a linear sea level rise of 0.76 meters (2.5 feet) feet by 2100, with a predicted Golden Gate sea level rise for 50th percentile in RCP 8.5 emission scenario. Only sea level rise over the next 10 years was taken into account.

ΔES is the change in elevation from subsidence within 10 years. For each pixel in the DEM the rate of change is given by the subsidence rates estimated in Deverel et al. (2016) based on organic soil composition.

The target for acres was calculated by comparing intertidal zone at IT_1 to IT_{10}. The area of the intertidal zones that was in IT_1 but not IT_{10} was calculated. In the Delta, that area was about 3,500 acres. In Suisun Marsh, the area was about 3,000 acres.

Target Methods – Locations Where Ongoing Subsidence Reversal Activities can Reach Intertidal Elevations by 2100

The subsidence reversal zone was calculated using the following formula (see Appendix 2 for an illustration of the methods), assuming a beginning date of 2020 and end date of 2100. The formula produces the band of elevation where ongoing subsidence reversal techniques would accrete land to reach intertidal elevations and prevent the net loss of opportunities to restore tidal wetlands to benefit the ecosystem. This analysis assumes that subsidence reversal activity would be halted once the landscape reaches intertidal elevations.

This was calculated using this given equation:

$$SRT = (MLLW > E) \cup (E - \Delta SLR + \Delta E)$$

SRT is the subsidence reversal target zone. It is areas at intertidal elevation by 2100, given subsidence reversal is used during that period to increase elevations.

Where ***E*** is elevation based on the Delta and Suisun Marsh DEM (Tolentino 2017) which was aggregated to 200m^2. The DEM was aggregated due to computational limitation. Running the landscape model for multiple scenarios on the aggregated DEM required large live memory resources that dramatically slowed the processing. The aggregation to 200m^2 improved processing. It was determined that local conditions at a smaller scale likely would better suited for a site-specific analysis conducted by a project proponent rather than a landscape level analysis. The aggregation level of 200m^2 was chosen because it is discrete enough to be smaller than any reasonable project, but large enough ease any computational bottlenecks.

MLLW is tidal datum for mean lower low water levels.

MHHW is tidal datum for mean higher high water levels.

ΔSLR is expected sea level rise. This analysis assumes a sea level rise of 0.76 meters (2.5 feet) by 2100, with a predicted Golden Gate sea level rise for 50th percentile in RCP 8.5 emission scenario.

ΔE is the change in elevation from subsidence reversal by 2100. The mapped band is based on rates of sediment accretion of 4 cm/yr from Miller et al. 2008.

The target locations identify areas where continued subsidence reversal at 4 cm/yr sediment accretion rate could reach intertidal elevations by 2100. (Figure 2).

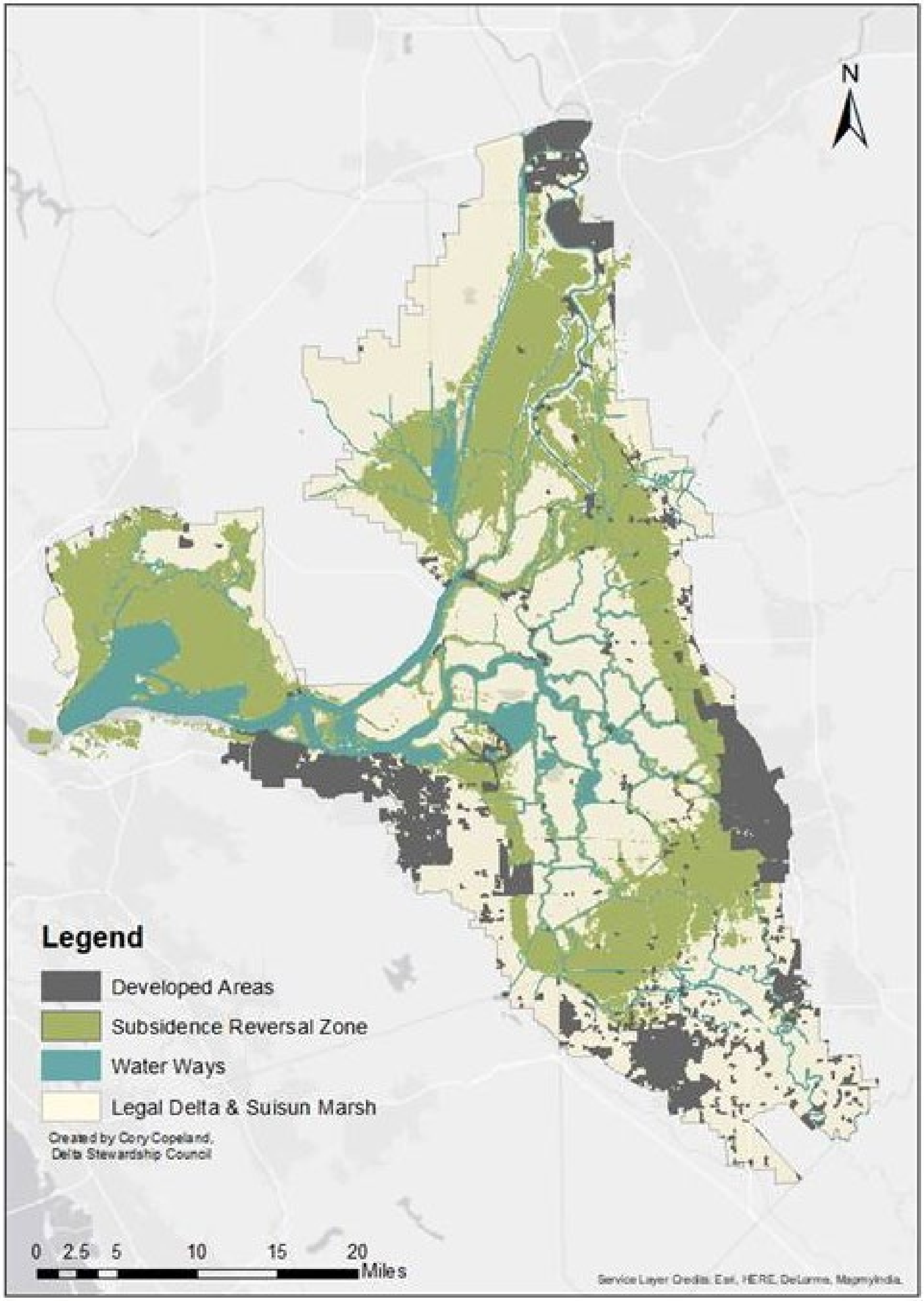

Figure 2. Areas Where Subsidence Reversal Activities, Ongoing from 2030 to 2100, Can Produce Intertidal Elevations by 2100

Figure 2. Areas Where Subsidence Reversal Activities, Ongoing from 2030 to 2100, Can Produce Intertidal Elevations by 2100 (contd.)

Within the boundaries of Suisun Marsh and the Delta, which are drawn as solid gray lines with a solid tan fill, this map illustrates the subsidence reversal zone. The subsidence reversal zone consists of the areas in the Delta and Suisun Marsh (at a 200-meter resolution) that, according to the elevation model used in this performance measure (described in Appendix 1) could reach intertidal elevations through subsidence reversal by 2100.

The subsidence reversal zone covers most of Suisun Marsh and Cache Slough. Concentrated areas in the north Delta, between the Sacramento Deep Water Ship Channel and the Sacramento River, and in the South Delta, north of Tracy and Lathrop, are within the subsidence reversal zone. A band of land surrounding the central Delta is also included in the subsidence reversal zone. Most of the central Delta is not included in the subsidence reversal zone, except for very small and scattered patches of land along the sloughs and rivers. There is minimal land within the subsidence reversal zone at edges of the Suisun Marsh and Delta, where land is above the tidal range.

Alternative formats of this map are available upon request.

This map shows all of the areas in the Delta that are presently at intertidal and shallow subtidal elevations. If subsidence reversal activities are implemented, and these activities continue to accrete land elevation, these areas will reach intertidal elevation by 2100 or sooner. The year 2100 serves as a conservative cutoff. Although there are uncertainties, if the best available science indicates that an area cannot reach intertidal by at least 2100, assuming the conservative assumptions built into the model, then the land is likely too deeply subsided to achieve intertidal elevations through subsidence reversal alone. Developed areas are shown on the map for illustrative purposes.

Appendix 2: Islands at Appropriate Locations

List of islands at appropriate locations to reach elevations that would support potential intertidal restoration by 2100:

DREXLER POCKET
HONKER LAKE TRACT
BRACK TRACT
GRAND ISLAND
TERMINOUS TRACT
MERRITT ISLAND
TYLER ISLAND
PEARSON DISTRICT
SUTTER ISLAND
SHIN KEE TRACT
BISHOP TRACT
LITTLE EGBERT TRACT
EHRHEARDT CLUB
RYER ISLAND
UPPER ANDRUS ISLAND
DEAD HORSE ISLAND
FAY ISLAND
FABIAN TRACT
SHIMA TRACT
SMITH TRACT (LINCOLN VILLAGE)
BYRON TRACT
LISBON DISTRICT
CACHE HAAS AREA
RIO BLANCO TRACT
DREXLER TRACT
WRIGHT-ELMWOOD TRACT
NEW HOPE TRACT
CANAL RANCH TRACT
HOTCHKISS TRACT
WINTER ISLAND
ATLAS TRACT
EGBERT TRACT
NETHERLANDS
PROSPECT ISLAND
GLANVILLE
MCCORMACK-WILLIAMSON TRACT
MAINTENANCE AREA 9
DLIS-11
DLIS-20 (YOLO BYPASS)
CHIPPS ISLAND
MEIN'S LANDING
DLIS-26 (MORROW ISLAND)
DLIS-63 (GRIZZLY ISLAND AREA)
DLIS-48
SUNRISE CLUB
DLIS-52
HONKER BAY
DLIS-62
DLIS-40
DLIS-41 (JOICE ISLAND AREA)
CHIPPS ISLAND SOUTH
DLIS-55
DLIS-47
DLIS-46
DLIS-30
DLIS-36
DLIS-25
DLIS-28
DLIS-29
DLIS-39
DLIS-31 (GARABALDI UNIT)
DLIS-32
DLIS-33
DLIS-44 (HILL SLOUGH UNIT)
DLIS-37 (CHADBOURNE AREA)
DLIS-5
DLIS-49
DLIS-50
UNION ISLAND EAST
UNION ISLAND WEST
MIDDLE ROBERTS ISLAND
LOWER ROBERTS ISLAND
VEALE TRACT
HASTINGS TRACT

Island identifications are those used in the Delta Levee Investment Strategy.

For Assistance

For assistance interpreting the content of this document, please contact Delta Stewardship Council staff.

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Phone: 916-445-5511

Performance Measure 4.13: Barriers to Migratory Fish Passage

Performance Measure (PM) Component Attributes

Type: Output Performance Measure

Description

Remediate fish passage at priority barriers and select large rim dams in the Sacramento-San Joaquin River watershed, and screen priority diversions along native, anadromous fish migration corridors within the Delta.[1]

Expectations

Remediating priority fish migration barriers and large rim dams, and screening Delta diversions improves fish migration, reduces fish entrainment, enhances aquatic habitat connectivity, and contributes to anadromous species recovery.

Metric

Priority fish migration barriers and select large rim dams in the Sacramento-San Joaquin River watershed, and unscreened diversions along native, anadromous fish migration corridors in the Delta and Suisun Marsh. This metric will be evaluated annually.

Baseline

Number of fish passage barriers, large rim dams, and unscreened diversions listed in:

1. California Department of Fish and Wildlife (CDFW) 2018 Priority Barriers.

[1] *Remediate* in this context means to provide passage upstream and downstream to migratory fish by constructing, modifying, or removing a barrier.

- For rim dams, remediate means implementing a long-term fish passage program that may include capture, transport, and release of fish at different life stages.
- For unscreened diversions, remediate means to screen the diversion so that juvenile andand adult fish are physically protected from entrainment.

2. Central Valley Flood Protection Program (CVFPP) 2016 Conservation Strategy (Appendix K).
3. Large rim dams in the Sacramento–San Joaquin River watershed identified in the National Marine Fisheries Service's Central Valley Recovery Plan for Central Valley Salmon and Steelhead (2014) with recovery actions.
4. Unscreened diversions along Delta native, anadromous migration corridors listed in the Passage Assessment Database (PAD March 2018 version).

Target

1. By 2030, remediate all (100 percent) priority barriers identified in the 2018 CDFW priority barriers list. For subsequent updates, remediate 100 percent within 10 years of being included in the priority barrier list.
2. By 2030, remediate all (100 percent) of the priority fish migration barriers listed in CVFPP 2016 Conservation Strategy.
3. By 2050, remediate fish passage at all (100 percent) large rim dams in the Sacramento-San Joaquin River watershed.
4. By 2030, prioritize all (100 percent) unscreened diversions along native, anadromous fish migration corridors in the Delta, and by 2050 screen all (100 percent) priority diversions.

Basis for Selection

General Purpose

Several species of native, anadromous fish travel through the Delta and upstream as part of their lifecycle. Instream barriers or unscreened diversions of water from the streams can impede migratory movements. These obstacles can limit or cut off access to spawning and rearing grounds, and to areas that offer refuge from predation, exacerbating stressors that adversely affect overall species survival (CDFW et al. 2014, NMFS 2009 and 2011). Remediating fish passage barriers and screening diversions to prevent fish from being drawn into (entrained) water diversion pipes, is important for the survival of several listed species, including salmonids that migrate through the Delta (CDFW et al. 2014, Merenlender and Matella 2013).

Rim dams are large dams along the rim or edge of the Sacramento and San Joaquin watersheds and Sierra Nevada mountains (Herbold et al. 2018). It is necessary to provide fish passage above rim dams so that fish can access high-elevation, cooler habitat (NMFS 2009).

Remediating all barriers to allow for volitional[2] fish passage will be challenging – especially large rim dams that provide water supply and flood control benefits. However, removing in-stream barriers and implementing fish passage programs at rim dams contributes to native fish population recovery, and increases species resilience and genetic diversity, among other benefits (CDFW et al. 2014, DWR 2014).

This performance measure tracks in-stream fish migration barriers and large rim dams that remediated fish passage to allow for migratory fish to travel upstream and downstream from the barrier. Screening of an unscreened diversion means juvenile or adult fish are physically protected from entrainment.

Barriers, Diversions, and Nonstructural Impediments

The term *barrier* can refer to several different types of impediments including dams, weirs, and low-flow road crossings such as culverts. Barriers can be partial or complete. Some barriers can change with instream flow, and are therefore affected by water year type, weather, sediment loads, and other factors. The term *unscreened diversions* refer to structures that divert water such as water diversion pipes that are not screened and may entrain fish. Water diversion pipes pose a risk to fish, especially salmon and steelhead (Vogel 2011), but also other native species such as Delta smelt, longfin smelt, sturgeon, and Pacific lamprey. Installing fish screens at these diversions is an effective means of preventing fish entrainment (Poletto et al. 2015, Goodman et al. 2017).

Barriers to migration and unscreened diversions are two of many factors affecting fish survival. Other factors include predation, food availability, suitable habitat and refuge, and water temperature (DWR 2014). The size of a fish population and its use of different migration routes are also important (Perry and Skalski 2008). The importance of different migration routes depends on factors such as flow, water operations, and infrastructure. For example, when the Delta Cross Channel is closed, a lower proportion of migrating fish pass through the interior Delta (Perry and Skalski 2008), reducing the negative impact on fish migration of unscreened diversions or barriers in the interior Delta.

In addition to the Delta's importance to fish migration, the Delta provides important nonnatal rearing habitat. In a study of Endangered winter-run Chinook salmon on the Sacramento River by Phillis et al. (2018), early winter-run Chinook appear to exit their

[2] *Volitional* in this context means fish have the opportunity to travel upstream and downstream of the remediated barrier without any human intervention.

natal Sacramento River to rear for extended times at nonnatal habitats (other tributaries) and/or further downstream in the Delta prior to entering the ocean.

Within the Delta, reduced survival during migration may result from a combination of lack of suitable refugia and food sources, challenging environmental conditions (e.g., water temperature), and the cumulative effect of unscreened diversions. There are over 1,458 unscreened diversions on the Delta primary fish migration corridors (SFEI-ASC 2018) with thousands more throughout Delta channels and sloughs (CalFish Passage Assessment Database 2019). While the number of unscreened diversions and the volume of water being diverted can possibly impact fish populations, fish screening can be useful conservation tools to minimize loss of fish (Moyle 2002). Due to limited resources and the large number of these unscreened diversions in the Delta, priority should be given to gathering additional field data about each site (see New ER Recommendation “H”) to allow prioritization and ranking of unscreened diversions for screening.

Rim Dams

Complete barriers are a major obstacle in the Sacramento and San Joaquin River watersheds. Large rim dams in particular have dramatically altered fish passage and access to upstream, cold water spawning habitat (Herbold et al. 2018). Rim dams are estimated to have cut off access for salmonids to approximately 80 percent of their pre-dam accessible habitat (Lindley et al. 2006). This habitat is especially valuable because it is at higher elevation, influenced by snowmelt, and could provide an important climate refuge as water temperatures rise over the remainder of the 21st century. Without access to this habitat, native runs of salmon may become extinct over the coming century. The National Marine Fisheries Service’s (NMFS) Recovery Plan for Central Valley Salmon and Steelhead establishes recovery actions to conduct Central Valley-wide assessment of anadromous salmonid passage opportunities at large rim dams, including assessing quality and quantity of upstream habitat, passage feasibility and logistics, and passage-related costs (NMFS 2014).

The 2009 Biological Opinion on Long-Term Operations of the Central Valley Project and State Water Project (BiOp) notes there are likely to be large impacts on salmonid populations due to inadequate cold water available downstream of large rim dams, especially in dry and critically dry years (NMFS 2009, pp. 659-660). Because of the importance of habitat above large rim dams, it is important to continue to study and find creative solutions to facilitate fish passage past large rim dams.

Climate change introduces new stressors to migratory salmon in the Sacramento and San Joaquin watersheds, including higher water temperatures and more frequent extreme weather events such as droughts. Central Valley rim dams block access to historical, cold-water spawning habitat. A spatially explicit model of salmon population dynamics for Butte Creek indicates that due to flow limits and high temperatures, salmon in the system are vulnerable to extinction without access to upstream areas (Thompson et al. 2012). Historically, the climate has been variable in the Central Valley of California, and salmon have had access to heterogeneous habitats, and genetic and phenotypic diversity among populations was high, resulting in population resilience (Herbold et al. 2018). Current salmon fisheries management seeks to improve salmon adaptive capacity in response to climate change by reconnecting and restoring habitats to facilitate ecosystem processes, providing refuge from temperature stress and predation risk as well as increasing food availability (Crozier et al. 2019).

Prioritization of Barriers

Due to a large number of fish passage barriers located within the Sacramento-San Joaquin watershed, resource agencies prioritize the most important barriers to remediate. CDFW and DWR have different methods of barrier / diversion prioritization but have the same goal of providing fish passage to anadromous fish.

1. CDFW 2018 Priority Barriers, Including Priority Barriers in North Central and Central Regions (Sacramento and San Joaquin River Watersheds)

CDFW Priority Barriers lists prioritize barriers across both coastal and Central Valley watercourses based on these criteria:

1. high likelihood to improve migration for anadromous species
2. availability of recent data of fish and habitat
3. willing partners and land access
4. known political support at a local, state, or national level
5. the site is a barrier to a federal recovery plan "core" population
6. the watercourse is an eco-regional significant watershed
7. CDFW is committed to monitoring before, during and after any barrier improvement project is undertaken
8. the site is considered to be a *keystone barrier*, meaning the barrier was the lower-most in that river or creek

The CDFW priority barrier list is updated on an annual basis with remediated barriers being removed from the list and new barriers being added to the list. Barriers that remain on the annually updated list are not yet remediated (due to factors such as funding, access, or other issues) and continue to be a priority. Remediated barriers are verified by CDFW PAD staff before they are removed from the priority lists (PAD data standards 2014; T. Schroyer, personal communication).

2. Central Valley Flood Protection Plan (CVFPP) Conservation Strategy, Appendix K (DWR 2016), Including the Central Valley Flood System Fish Migration Improvement Opportunities (FMIO) study (DWR 2014)

DWR's CVFPP contains prioritized fish passage barriers in the Central Valley Flood System Fish Migration Improvement Opportunities (FMIO) study and Appendix K of the CVFPP Conservation Strategy. The fish barriers are prioritized using dual metrics in each of the following three categories:

1. Barrier frequency:
    a. Waterway hydrology – frequency of migratory corridor containing water.
    b. Barrier status – total barrier, partial barrier, or temporal barrier.
2. Barrier intensity:
    a. Barrier location in the target area – barriers are given a score to reflect their spatial distribution in the target area. Highest scores for anadromous species are given to barriers farthest downstream.
    b. Species diversity/presence – number of anadromous species that can reach the barrier from upstream or downstream.
3. Upstream habitat:
    a. Upstream miles of waterway – when comparing two or more barriers, the barrier with the most upstream miles of habitat (to the next barrier) gets the highest score.
    b. Type of upstream habitat – spawning, rearing, and holding habitats.

DWR's priority barriers list does not consider diversions, and there are no plans to regularly update DWR prioritization lists. The lists from these studies are included because they represent the most in-depth analysis of barriers, and opportunities for improvements, currently available.

Large Rim Dams in the National Marine Fisheries Service's Recovery Plan

The National Marine Fisheries Service's (NFMS) Recovery Plan for Central Valley Salmon and Steelhead establishes a strategic approach to recovery which identifies critical recovery actions for the Central Valley as well as watershed and site-specific recovery actions (NOAA 2014, p 102). Each major tributary to the Central Valley watershed contains specific recommended recovery actions including evaluating fish passage at large rim dams.

Unscreened Water Diversions

CDFW has prioritization criteria specific to unscreened diversions and develops a priority list of regional annual water diversions for screening based on the following ranking criteria: presence of listed and at-risk species, number of other diversions in the watershed, location of the diversion, intake orientation, duration of pumping, and ongoing efforts in cooperation with the diverter to screen the facility.

However due to limited surveys and access within the Delta, water diversions within the Delta lack sufficient details to be able to apply the ranking criteria to them (T. Schroyer, personal communication). Therefore, a first step in prioritizing unscreened diversions within Delta is to gather the additional field data (see New ER Recommendation “H”).

Linkages to Delta Reform Act and the Coequal Goals

Delta Reform Act

Habitat fragmentation and limited access to spawning and rearing grounds are major stressors to conservation and recovery of salmon species. Entrainment of fish into unscreened water diversions increases mortality of native resident and migratory fish species. Achieving the target in this performance measure would support the following characteristics of a healthy Delta, as identified in the Delta Reform Act:

- **“Viable populations of native resident and migratory species.” (Water Code section 85302(c)(1)).** Remediating instream barriers and screening Delta diversions is important for the survival of several listed species by improving fish migration, reducing fish entrainment, enhancing aquatic habitat connectivity, and contributing to anadromous species recovery.
- **“Functional corridors for migratory species.” (Water Code section 85302(c)(2)).** Instream barriers and unscreened water diversions impede migratory movements, and they limit or cut off access to spawning and rearing grounds and areas that offer refuge from predation (CDFW et al. 2014, NMFS 2009 and 2011). Remediating instream barriers and screening Delta diversions restores corridors for migratory species, enhances aquatic habitat connectivity, and opens access to salmon spawning and rearing grounds.
- **“Reduced threats and stresses on the Delta ecosystem.” (Water Code section 85302(c)(4)).** Instream barriers and unscreened water diversions exacerbate stressors that adversely affect migratory fish species (CDFW et al. 2014, NMFS 2009 and 2011). Allowing migratory salmon to access historical, cold-water spawning habitat blocked by rim dams will improve salmon adaptive

capacity by providing refuge from temperature stress and predation risk (Crozier et al. 2019).

- **"Conditions conducive to meeting or exceeding the goals in existing species recovery plans, and state and federal goals with respect to doubling salmon populations."** (Water Code section 85302(c)(5)). Meeting the target of this measure will contribute to the recovery of salmon populations by improving fish migration and opening access to additional spawning and rearing grounds.

Achieving the target in this performance measure supports the following subgoal and strategy for restoring a healthy ecosystem: **"Establish migratory corridors for fish, birds, and other animals along selected Delta river channels." (Water Code section 85302(e)(2)).**

This performance measure tracks priority fish migration barriers. Remediating fish passage at priority barriers restores corridors for migratory species, enhances aquatic habitat connectivity, and opens access to salmon spawning and rearing grounds, contributing to the Doubling Goal for Central Valley Chinook Salmon Natural Production (PM 4.6).

Delta Plan Core Strategy

4.4 Protect Native Species and Reduce the Impact of Nonnative Invasive Species.

Methods

Baseline Methods

The baseline is all of the priority barriers identified by CDFW and DWR—99 Large rim dams in the Sacramento-San Joaquin Delta watershed, and 1,458 unscreened diversions along migratory routes in the Sacramento-San Joaquin Delta and Suisun Marsh.

The **priority barriers** listed in Tables 1 and 2 below are based on the CDFW 2018 Regional Fish Passage Priority List and DWR's CVFPP Conservation Strategy (Appendix K, 2016). The methods used by CDFW and DWR to select these barriers are described in the "Basis for Selection" section (p. 6-7) of this document. DWR stated that there will be no regular updates to their list, thus the list will remain as a static baseline (consisting of the current barriers in Tables 1 and 2 under column two). While CDFW updates their priority barrier lists annually, the performance measure target is based on the CDFW 2018 Regional Fish Passage Priority List.

The **large rim dams** identified (Table 3 in Methods) were selected because of their targeted recovery actions specified in the National Marine Fisheries Service's (NMFS) 2014 Recovery Plan. Each river identified contains several listed recovery actions. The Recovery Plan identifies an action for most rivers in the Central Valley involving large rim dams and smaller downstream dams, which calls for planning for development and/or implementation of a program to reintroduce salmon species and steelhead to historic upstream habitats. NMFS recommends that programs should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot project. Each recovery action also identifies potential collaborators, duration, and estimated costs (NMFS 2014). Current examples of fish passage programs are shown in the "Interim Performance Assessment" section of this document.

The **Delta unscreened diversions** baseline was identified by using the PAD March 2018 GIS layer. The data was filtered for "SITETYPE" = "diversions" and "BarStatus" = "unscreened" and clipped to only count diversions within the Delta. Next, it was further clipped to only count unscreened diversions that are on anadromous fish migration corridors. The total count of unscreened diversions is 1,458.

Table 1. Comparative List of Priority Fish Migration Barriers Identified in the Sacramento River Watershed

Sacramento River Fish Migration Barriers	Priority Barrier in CVFPP 2016 Conservation Strategy	Priority Barrier in CDFW 2018
Lisbon Weir	Yes	No
Yolo Bypass Road Crossings	Yes	No
Cache Creek Settling Basin	Yes	No
Fremont Weir[1]	Yes	Yes
Oroville-Thermalito Complex	Yes	No
Knights Landing Outfall Gates (KLOG)[2]	Yes	No
Tule Canal Crossings	Yes	No
Sacramento Weir	Yes	No
Sunset Pumps Diversion Dam	Yes	Yes
Sutter Bypass Weir No. 1	Yes	Yes
Sutter Bypass (multiple structures)	Yes	No
Tisdale Weir	Yes	Yes
Moulton Weir	Yes	No
One-Mile Dam	Yes	Yes
Big Chico Creek Gates (Five-Mile Dam)	Yes	Yes
Lindo Channel Gates	Yes	No
Sewer Pipe Crossing, Dry Creek	No	Yes
Battle Creek Restoration Project Dams (8 total barriers)	No	Yes
Antelope Creek Edwards Diversion	No	Yes
Deer Creek Stanford Vina Dam Fish Ladders		Yes
Mill Creek Fish Passage Project - Upper Dam		Yes

Sources: DWR 2016 and CDFW 2018

Key:
CDFW = California Department of Fish and Wildlife
CVFPP = Central Valley Flood Protection Plan

Notes:
[1] Upstream migration over the Fremont Weir was partially addressed in 2018. However, it remains a barrier to downstream migration until overtopping under high flow conditions.
[2] The KLOG had operational gates added in 2015 as part of the EcoRestore project. It is operated as an intentional barrier to keep migrating salmonids in the mainstem of the Sacramento River, under certain conditions.

Table 2. Comparative List of Priority Fish Migration Barriers Identified in the San Joaquin River Watershed

San Joaquin River Fish Migration Barriers	Priority Barrier in CVFPP 2016 Conservation Strategy	Priority Barrier in CDFW 2018
San Joaquin River Headgates	Yes	No
Sack Dam	Yes	Yes
Mendota Dam	Yes	Yes
San Joaquin River Control Structure	Yes	No
Donny Bridge	Yes	No
Lost Lake Rock Weir #1 (Lower)	Yes	No
Mariposa Bypass Control Structure	Yes	No
Mariposa Bypass Drop Structure	Yes	No
Eastside Bypass Rock Weir	Yes	No
Eastside Bypass Control Structure	Yes	No
Dan McNamara Road Crossing	Yes	No
Merced Refuge Weir #1 (Lower)	Yes	No
Merced Refuge Weir #2 (Upper)	Yes	No
Avenue 21 County Bridge	Yes	No
Ave 18½ County Bridge	Yes	No
Pipeline Crossing	Yes	No
Eastside Bypass Drop 2 (Upper)	Yes	No
Bellota Weir	No	Yes
Merced River Cowell Agreement Diverters (CAD) Wingdams (7 total barriers)	No	Yes
Eastside Bypass Drop 1 (Lower)	Yes	No
Chowchilla Bypass Control Structure	Yes	No
Hosie Low Flow Road Crossing	No	Yes
Central California Traction Railroad Bridge	No	Yes

Sources: DWR 2016 and CDFW 2018

Key:
CDFW = California Department of Fish and Wildlife
CVFPP = Central Valley Flood Protection Plan

Table 3. Large Rim Dams Identified in Recent Recovery Plan Biological Opinion for Central Valley Chinook Salmon and Steelhead Passage

Rim Dam Name	Associated Downstream Dams	Tributary Name	Watershed
Shasta Dam	Keswick Dam	Sacramento River	Sacramento River
Folsom Dam	Nimbus Dam	American River	Sacramento River
Oroville Dam	Thermalito Diversion Dam	Feather River	Sacramento River
New Bullards Bar Dam	Englebright Dam and Daguerre Point Dam	Yuba River	Sacramento River
Friant Dam	N/A	San Joaquin River	San Joaquin River
New Melones	Goodwin and Tulloch Dam	Stanislaus River	San Joaquin River
New Don Pedro	La Grange Dam	Tuolumne River	San Joaquin River
New Exchequer Dam	Crocker-Huffman Dam Merced Falls Dam McSwain Dam	Merced River	San Joaquin River
Pardee Dam	Camanche Dam	Mokelumne River	San Joaquin River

Source: NMFS 2014 and 2009

Target Methods

The **DWR's CVFPP priority barriers** will have a target of 100% remediation of the listed barriers by 2030. A 100% remediation target by 2030 was selected due to several current timelines and estimates of fish passage barrier remediation projects. Some fish passage barrier projects are already being implemented such as the Fremont Weir in the Yolo Bypass and Mendota Dam on the San Joaquin River. Other barriers such as Lisbon Weir, Yolo Bypass Agricultural Crossings, and East Side Bypass on the San Joaquin River will begin project implementation in 2020 or planned for in the following years. Additional assessment needs for barriers are identified in Appendix K of the CVFPP.

CDFW's priority barrier list is updated annually and has a target of 100% remediation of the listed barriers within 10 years of the barrier being listed in the priority list. Each new barrier listed in subsequent lists will be tagged with the year it was added to the priority list. A 100% remediation target within 10 years was selected because it provides enough time for the responsible agencies to carry out the remediation. In addition, a 10-year time frame is considered to be a realistic goal (T. Schroyer, personal communication).

- E.g. 2018 Priority Barriers (last updated October 2019) will have a target of 100% remediation by 2030. Barriers added in 2022, will have a 100% remediation target by 2032 and so on.

Large rim dams are to be 100% remediated by 2050. This metric will depend on future or current feasibility studies being completed and fish passage programs being implemented. Further discussion about feasibility studies are located in the "interim performance assessment" section.

Unscreened diversions will have a target of 100% remediation by 2050. This metric will depend on future prioritization schemes because it is currently limited within the Delta compared to other regions. Identifying priority water diversions for screening using ranking criteria specific to unscreened diversion is set as a near-term target (100% prioritized by 2030). Screening of all priority diversions is expected by 2050.

Data Sources

Primary Data Sources

This primary data source will be used for tracking this performance measure annually:

1. California Fish Passage Assessment Database (PAD). The PAD is an "inventory of known and potential barriers to anadromous fish in California," and includes all instream dams, including the rim dams, in the Sacramento-San Joaquin River watershed. The PAD database reports the fish passage status of the barriers, dams, and unscreened diversions.
    a. Content: Updated fish passage status of remediated barriers.
    b. Update frequency: Three times per year.

Alternative Data Sources

Alternative data sources will be used if the primary data sources become unavailable or insufficient. These data sources were used in compiling the passage priorities, and updates to fish passage barrier priorities can be used concurrently with the primary data sources as a reference, or as supplemental information.

1. CDFW Watershed Restoration Grants Branch. CDFW provides a list of fish passage priorities in grant proposal solicitation notices. Proposition 68 awards grants to projects that improve a community's ability to adapt to the unavoidable impacts of climate change; or ones that improve and protect coastal and rural economies, agricultural viability, wildlife corridors, or habitat. Proposition 1 awards grants to projects that meet objectives of reliable water supplies, restoration of important species and habitat, and more resilient, sustainably managed water resources system.
    a. Content: Updated prioritization of fish passage barriers to be available for Prop 1 and Prop 68 proponents.

    b. Update frequency: Annually.

2. Updates to Central Valley Flood Protection Plan (CVFPP) Conservation Strategy. DWR updates the Conservation Strategy as a system-wide conservation plan to support integrated flood system planning and integration of environmental stewardship into the CVFPP.
    a. Content: Updated prioritization of fish passage barriers within the Central Valley Flood Protection Plan.
    b. Update frequency: Every five years.

Process

Data Collection and Analysis

Every year, Council staff will update the status of this performance measure by:

1. For all of the identified priority barriers in the PAD priority list (Table 1 and 2), identify those that were remediated each year by downloading their new priority lists at calfish.org.
    a. Add additional barriers to the overall measure list (tagged with the year of their addition) that were added to the PAD priority list.
        i. Count the total number of barriers that were remediated with verification from CDFW staff.
        ii. Update the number of total remediated barriers for CDFW, with context for each barrier if possible.
2. For the identified barriers in DWR's CVFPP priority barriers (Tables 1 and 2), contact DWR staff to receive information about priority barrier status.
    a. If any of the listed barriers are remediated, update the number of total remediated barriers for the CVFPP list with context for each barrier if possible.
3. For large rim dams, contact the responsible agencies (U.S. Department of the Interior, Bureau of Reclamation (Reclamation); U.S. Army Corps of Engineers; etc.) regarding the statuses of feasibility studies, pilot programs, and other fish passage related efforts. Any relevant efforts at these dams will be actively tracked and noted.
4. For unscreened diversions:

a. Review results of CDFW water diversions screening prioritization and inquire about the status of the prioritization scheme for unscreened diversion within the Delta.

b. To view status of unscreened diversions remediation, download the most recent PAD GIS dataset (annually updated) and check the total number of unscreened diversions. Verify with CalFish staff if the number if accurate and for context.

Interim Performance Assessment

Along with the annual evaluation and tracking of this performance measure, performance assessment in relation to interim milestones will be conducted every five years, coinciding with the Delta Plan five-year review process. The interim milestones are set to allow for assessment of short-term progress toward the performance targets.

Interim Milestones – Priority Barriers

1. Interim progress will be tracked against the baseline 2018 priority list with a milestone of 50% remediated barriers by 2025.
2. CDFW conducts a statewide fish passage barrier prioritization process annually. Annual changes to prioritized barriers (additional barriers) will be tracked and compared to the 2018 baseline barriers.
   a. Council staff will coordinate with CDFW fish passage coordinator to obtain contextual information for newly added and removed priority barriers, and inquire about priorities, timelines, and feasibility.
3. Updates or changes to the CVFPP priority barrier list are not expected. Interim milestone is remediation of 50% of priority barriers by 2025.

Interim Milestones - Rim Dams

4. Fish passage feasibility studies initiated, ongoing, or completed for the listed large rim dams.
   a. If fish passage is found feasible at the dam site, this PM will track and report the progress of the study and recovery plan.
   b. If fish passage is found infeasible at the dam site, what additional efforts are being conducted to remediate Rim Dams?
   c. Are there current feasibility studies being conducted? Progress on existing efforts will be tracked including:
      i. Reclamation's Shasta Dam Fish Passage Evaluation, https://www.usbr.gov/mp/bdo/shasta-dam-fish-pass.html. This is part of

Reclamation's Fish Passage program that involves evaluation of the reintroduction of winter-run and spring-run Chinook salmon and steelhead above Shasta Dam. The goal is to increase the geographic distribution, abundance, productivity, and spatial distribution, and to improve the life history, health, and genetic diversity of the target species. Folsom and New Melones Dams are also included in Reclamation's Fish passage program and will be addressed in independent planning studies (Reclamation 2015).

ii. Yuba Salmon Partnership Initiative. (YSPI) http://www.dfg.ca.gov/fish/Resources/Chinook/YSPI/. The YSPI is a collaboration between CDFW, NOAA, Yuba County Water Agency, and several other entities to return spring-run Chinook salmon and possibly steelhead to more than 30 miles of the north Yuba River (New Bullards Bar dam). The program would truck juvenile salmon in the winter downstream and recover them in spring to be trucked up New Bullards Bar dam (YSPI 2015).

iii. The Turlock Irrigation District and Modesto Irrigation District included a fish passage assessment for reintroduction of anadromous fish above Don Pedro Dam in their Environmental Impact Statement for Hydropower Licenses, https://www.ferc.gov/industries/hydropower/enviro/eis/2019/02-11-19-DEIS/P-2299-082-DEIS.pdf. Additional information of their efforts regarding fish passage can be found in the document at pages 3-162 to 3-170.

iv. The Upper Mokelumne Salmonid Restoration Team (SRT) is a collaboration of state, federal, local, and NGO agencies that aims to reestablish a successfully reproducing population of fall-run Chinook salmon and/or Central Valley steelhead in the upper Mokelumne River (Cramer Fish Sciences 2018). In 2018, they completed an assessment of the potential for Chinook salmon reintroduction above Pardee Dam, http://www.foothillconservancy.org/dl.cgi/1552580969_22399.f_doc_pdf.pdf/UM_2018_final.pdf.

5. Progress and findings from the Central Valley-wide assessment of anadromous salmonid passage opportunities at large rim dams including the quality and quantity of upstream habitat, passage feasibility and logistics, and passage-related costs (NOAA 2014).

Interim Milestones - Unscreened Diversions

6. Field data is collected at unscreened diversions, in addition to diversion size and site location, to provide additional information allowing prioritization of

unscreened diversions. The large majority of Delta agricultural diversions is below 100 cfs, but large unscreened diversions located on important migratory routes may remain.

7. Conduct prioritization of unscreened diversions for screening priorities following CDFW statewide prioritization protocol. The prioritization process includes contribution of the diversion to the cumulative loss of fishes to the system and the impact of this contribution on fish populations, especially those of declining species. Such an evaluation could help determine priorities for spending limited funds available for fish conservation (Moyle 2002 Memo).
8. Based on prioritization results, screen high priority barriers.

Process Risks and Uncertainties

As previously discussed in the basis for selection, it is unlikely that all in-stream barriers will be remediated but remediating the prioritized barriers will benefit native fish survival and resilience.

Large rim dams provide water supply and flood control benefits, and the technological solutions to upstream and downstream fish passage are complex. Interim steps include conducting Central Valley-wide assessment of anadromous salmonid passage opportunities. This also includes preparing site-specific feasibility studies to evaluate upstream habitat quality and quantity, passage feasibility and logistics, passage-related costs, and reintroduction of the species.

Similarly, to screen over 1,400 unscreened diversions within the Delta priority migration corridor is unlikely. Ranking the diversions for screening priorities is an important initial step to focus limited funds available for fish conservation for screening projects with highest impact of populations.

Process risks and uncertainties related to this measure are:

1. Environmental variability such climate, ocean, hydrology, freshwater flow, and native fish populations
2. Gaining land access and willing partners from landowners
3. Support from local, state, or federal agencies due to differing agency priorities and funding
4. Acquiring and implementing suitable fish passage technologies

Reporting

Every year, Council staff will report the status of this performance measure by:

1. Posting updates on the Performance Measures Dashboard.
2. Providing results in the Council's annual report (published in January).
3. Communicating management-relevant results at Council and Delta Plan Interagency Implementation Committee (DPIIC) public meetings.

Every five years, Council staff will assess and report the status of this performance measure by:

1. Communicating findings in the five-year review of the Delta Plan.
2. Informing the Council's adaptive management process and other decision-making.

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Performance Measure 4.14: Increased Funding for Restoring Ecosystem Function

Performance Measure (PM) Component Attributes

Type: Output Performance Measure

Description

Increased funding for projects that possess attributes to restore ecosystem functions and support a resilient, functioning Delta ecosystem.

Expectations

Increased funding for projects that restore hydrological and geomorphic processes, are large-scale, improve connectivity, support native vegetation communities, and contribute to recovery of special-status species contributes to restoring ecosystem functions and supports a resilient, functioning Delta ecosystem (Ecosystem Restoration Tier 1 or 2 attributes).

Metric

Project funding of covered actions that file a certification of consistency under New ER Policy "A" (Disclose Contributions to Restoring Ecosystem Function). This metric excludes funding for projects that do not include protection, enhancement, or restoration of the Delta ecosystem. This metric will be reported annually.

Baseline

Set at zero as of the effective date of New ER Policy "A."

Target

By 2030, 80 percent of total funding for covered action projects that file certifications of consistency with New ER Policy "A" is for projects with Ecosystem Restoration Tier 1 or 2 attributes.

Basis for Selection

To achieve the subgoals (Water Code section 85302(e)) for restoring the Delta ecosystem set forth in the Delta Reform Act, the Delta Plan recommends implementation of projects with specific priority attributes that restore ecosystem functions and support a resilient, functioning Delta ecosystem, and an increase in funding for those high priority projects. High priority projects restore hydrological and geomorphic processes, are large-scale, improve connectivity, support native vegetation communities, and contribute to recovery of special-status species. This measure tracks the total funding of high-quality conservation projects proceeding through the covered action process. A covered action, per Water Code section 85057.5, is a plan, program, or project as defined pursuant to Section 21065 of the Public Resources Code. This measure evaluates the percentage of funding for high-tier projects according to the definition in New ER Policy "A" (Chapter 4, Appendix 3A).

A project's tier is determined by project proponents, based on the expected ecosystem benefits for conservation projects in the Delta (Appendix 3A of the Delta Plan). New ER Policy "A" requires proponents to disclose which priority attributes their project supports. The priority attributes are characteristics of the protection, restoration, and enhancement projects which best available science indicates are critical to achieving the characteristics of a healthy Delta ecosystem. This is further described in Appendix 3A of the Delta Plan. Below is a summary of priority attributes for ecosystem restoration actions in the Delta:

1. **Restoring Hydrological, Geomorphic, and Biological Processes** – Targeting the reestablishment of hydrological, geomorphic, chemical, and biological processes in conservation projects, also termed *process-based restoration*, is key to improving habitat characteristics related to the spatial arrangement of habitat patches, vegetation community composition and structure, and habitat requirements of sensitive specialist species.
2. **Being Large-Scale** – Conservation projects that incorporate large spatial scales and long time frames will increase the likelihood of creating natural systems capable of sustaining desired functions in uncertain future environmental condition (Peterson et al. 1998, SFEI-ASC 2016). Critical biotic interactions and physical processes depend on appropriate levels of heterogeneity (Larkin et al. 2017) made possible by large-scale projects. Large intact core areas with minimal human intervention are important for facilitating the ecological interactions that are important to species persistence (Soule and Terborgh 1999).
3. **Improving Connectivity** – Connectivity is essential for the long-term persistence of native species. In the Delta, unobstructed flow through the channel system,

lateral connections between channels and floodplains, and horizontal connections between surface and groundwater are different facets of connectivity. Nutrient and carbon cycling, vegetation community patch dynamics, and species-habitat interactions improve with increased connectivity (Vannote et al. 1980, Naiman et al. 1988, Ward 1989, Junk et al. 1989, Poff et al. 1997, Naiman and Decamps 1997). The various aspects of connectivity are crucial to the ability of riparian and wetland systems to support biodiversity. Improving connectivity will increase ecosystem resilience and adaptive potential in the face of a rapidly changing climate (Naiman et al. 1993, Seavy et al. 2009).

4. **Increasing Native Vegetation Cover** – The loss of native vegetation cover has greatly reduced habitat complexity in the Delta over the last 160 years, completely altering aquatic and intertidal food-web dynamics (Moyle et al. 2010, Whipple et al. 2012). This loss of ecosystem complexity has been coupled with and exacerbated by substantial reduction in land-water connections (SFEI-ASC 2014 and 2016). Restoration of complex ecosystems will require reestablishment of native vegetation communities and the underlying processes that support their recruitment, disturbance regimes, and community succession. Restoring a variety of native vegetation cover types can promote ecological resilience and enhance native biodiversity by providing a range of habitat options for species, thus expanding the types and numbers of species that a landscape can support.
5. **Contributing to the Recovery of Special-Status Species** – At least 35 native plant species and 86 fish and wildlife species in the Delta are imperiled by human activities, and they are at varying risks of either local extirpation or outright extinction. Habitat loss and degradation, and the resulting impacts on food-web dynamics, have been a major cause of the at-risk status of these species. Supporting ecosystem function such as nutrient transfer and primary production is an important requirement for the recovery of these species.

Tier 1 projects have all five priority attributes. Tier 2 projects have priority attribute 5 (contributing to the recovery of special-status species) and three of the remaining four priority attributes. New ER Policy “A” (Disclose Contributions to Restoring Ecosystem Function) requires project proponents to disclose whether individual covered actions possess the listed priority attributes needed to certify consistency with the Delta Plan.

Linkages to Delta Reform Act and the Coequal Goals

Delta Reform Act

Achieving the Delta Reform Act vision for the Delta ecosystem, requires the reestablishment of tens of thousands of acres of functional, diverse, and interconnected habitat. Funding is needed to implement large-scale restoration projects and to support multi-benefit projects that go beyond impact mitigation. State and local land use actions, identified as *covered actions* pursuant to 85057.5, must be consistent with the Delta Plan (Water Code section 85022(a)). Per 85057.5, a covered action is a plan, program, or project as defined pursuant to section 21065 of the Public Resources Code that meets all of the following conditions:

1. Will occur, in whole or in part, within the boundaries of the Delta or Suisun Marsh
2. Will be carried out, approved, or funded by the state or a local public agency
3. Is covered by one or more provisions of the Delta Plan
4. Will have a significant impact on achievement of one or both of the coequal goals or the implementation of government-sponsored flood control programs to reduce risks to people, property, and state interests in the Delta

Projects with high-priority attributes that restore ecosystem functions and support a resilient, functioning Delta are critical to achieving the following characteristics of a healthy Delta ecosystem described in Water Code section 85302(c):

- “Viable populations of native resident and migratory species” (Water Code 85302(c)(1)).
- “Functional corridors for migratory species” (Water Code 85302(c)(2)).
- “Diverse and biologically appropriate habitats and ecosystem processes” (Water Code 85302(c)(3)).
- “Reduced threats and stresses on the Delta Ecosystem” (Water Code 85302(c)(4)).
- “Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations” (Water Code 85302(c)(5)).

Increased funding and consequently implementing projects with high-priority attributes contributes to improved “health of the Delta’s estuary and wetland ecosystem for supporting viable populations of aquatic and terrestrial species, habitats, and processes, including viable populations of Delta fisheries and other aquatic organisms” (Water Code 85211(a)).

Delta Plan Core Strategy

4.2 Restore Ecosystem Function.

Methods

Baseline Methods

Set at zero as of the effective date of New ER Policy “A”

Target Methods

The Delta Reform Act established a process for qualifying projects to establish consistency with the Delta Plan (Water Code section 85022). This means that a state or local agency proposing to undertake a qualifying action (covered action) must submit to the Council a written certification of consistency with detailed findings as to whether the covered action is consistent with Delta Plan regulations. Any person may appeal a certification of consistency to the Council.

The Council’s covered action website and the associated database (2020) provide access to the certified covered actions and related details, including the estimated project cost. Under New ER Policy “A,” certified projects include, when applicable, a disclosure of project tiers, priority attributes supported by the project, and information on the project cost.

Each certification of consistency has three sections. Section 1 is the agency profile where project proponents provide details about the agency filing to certify consistency with the Delta Plan. Section 2 is a covered action profile where the project proponent provides information about the covered action. The proponent discloses an estimated project cost along with a description of the project, a timeline, and other materials describing the project. The estimated project funding from this section of the consistency filing will be used as the primary data source. Section 3 is a policy-by-policy description of the project proponent’s findings regarding consistency with the Delta Plan. With regard to each policy, the proponent may find that the covered action is consistent, inconsistent, or that the policy is not applicable to the covered action. Any certification of consistency to which New ER Policy “A” applies will be tracked for this performance measure. A covered action will only be counted under this performance measure after a consistency certification has been filed.

Data Sources

Primary Data Sources

This is the primary data source to be used to track this performance measure:

1. Delta Plan Covered Actions Website. A state or local agency proposing to undertake a qualifying action (covered action) must submit a certification of consistency with detailed findings as to whether the covered action is consistent with the Delta Plan. Covered actions certifications are available on the Council's website.
    a. Content: Covered action certification of consistency document including disclosed amount of funding for the whole project (project cost).
    b. Update Frequency: As certifications are submitted.

Alternative Data Sources

Alternative data sources will be used if project funding is not disclosed on the Council's covered actions website. Alternative data sources can be used concurrently with the primary data source, depending on best available science and the availability of the primary source.

1. California Environmental Quality Act (CEQA) Clearinghouse
    a. Data Source: Project CEQA environmental impact report (EIR) includes cost of project alternatives considered. Covered actions have an associated EIR, as Delta Plan consistency certification is triggered by the CEQA process.
    b. Update Frequency: As EIR project files are submitted.

Process

Data Collection and Analysis

Every year, Council staff will update the status of this performance measure by:

1. Downloading covered actions project documents from the covered actions website that certify under New ER Policy "A." Funding only for projects that file a certification of consistency under New ER Policy "A" will be included. The calculation will exclude funding for projects that do not include protection, enhancement, or restoration of the Delta ecosystem (and will not need to certify under New ER Policy "A").
2. Summing the total cost of all projects under New ER Policy "A."
3. Filtering project documents by ecosystem restoration tier.
4. Summing the total cost of projects in ecosystem restoration Tier 1 and Tier 2.
5. Calculating the percentage of cost of projects in Tier 1 and Tier 2 with the total cost of all projects under New ER Policy "A."
6. Displaying results on the Performance Measures Dashboard.

Interim Performance Assessment

To evaluate short-term progress before the target date, an interim milestone is set as follows:

By 2025, 40 percent of the total funding for covered action projects that file certification of consistency with policy ER 'A' is for projects with Ecosystem Restoration Tier 1 or 2 attributes.

Process Risks and Uncertainties

A linear increase in percent of funding for projects with Ecosystem Restoration Tier 1 or Tier 2 attributes may not be a reasonable expectation due to long lead times in restoration projects' development and implementation. Uncertainty exists in time lags between a covered action filing of certification of consistency and on-the-ground implementation, and in the trajectory of restoring ecosystem functions.

Reporting

Every year, Council staff will report the status of this performance measure by:

1. Posting updates on the Performance Measures Dashboard
2. Providing results in the Council's annual report (published in January)
3. Communicating management-relevant results at Council and Delta Plan Interagency Implementation Committee (DPIIC) public meetings
4. Presenting findings at technical interagency groups, professional gatherings, and conferences

Every five years, Council staff will assess and report the status of this performance measure by:

1. Communicating findings in the five-year review of the Delta Plan.
2. Informing the Council's adaptive management process and other decision-making.

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Performance Measure 4.15: Seasonal Inundation

Performance Measure (PM) Component Attributes

Type: Outcome Performance Measure

Description

Restoring land-water connections to increase hydrologic connectivity and seasonal floodplain inundation.

Expectations

Increased hydrologic surface water connectivity and increased frequency of seasonal inundation contributes to achieving a healthy Delta ecosystem and viable populations of native species.

Metric

Acres within the Sacramento-San Joaquin Delta and Suisun Marsh that are:

1. Hydrologically connected to fluvial and tidally influenced waterways.
2. A nontidal floodplain[1] area that inundates[2] at least once every two years.

Metric will be evaluated annually.

Baseline

As of the year 2018:

1. An estimated 75,000 acres of land physically connected to the fluvial river and tidal system.

[1] Area that is inundated on a two-year recurrence frequency and is connected via surface water to the fluvial river or tidal system.
[2] There is no depth threshold for the inundation analysis, as inundation occurs at any depth. While depth of inundation is important for ecological processes, the available data do not include depth measurements.

2. Approximately 15,000 acres of the connected land inundated at a two-year interval, calculated as a long-term average for 1985-2018.

Target

By 2050:

1. Additional 51,000 acres added to the 75,000-acre baseline that are physically connected to the fluvial river and tidal system, for a total of 126,000 acres.
2. At least an additional 19,000 acres of nontidal floodplain area is inundated on a two-year recurrence interval, for a total of 34,000 acres.

Basis for Selection

Since the 1800s, 91 percent of historical wetland habitat in California has been lost (Dahl 1990), including 95 percent of Central Valley floodplain habitat (Opperman et al. 2010, Whipple et al. 2012). In the Delta, most of these wetlands and floodplains have been drained and converted to agricultural land use (SFEI-ASC 2014). Although most of the natural wetlands no longer remain, some agricultural land, floodways, and floodplains can provide similar functions, including greatly increased aquatic food production and transfer of nutrients to the fluvial system compared to other converted land uses (Moyle and Mount 2007, Corline et al. 2017, Katz et al. 2017). However, in order for these functions to be maintained or restored, areas must be hydrologically connected via surface water, and inundated for at least part of the year (Sommer et al. 2001a, Jeffres et al. 2008, Opperman et al. 2010, Katz et al. 2017).

The ecological health of the Delta is fundamentally dependent on the reestablishment of more natural inundation patterns and land-water connections. It is expected that increased area and frequency of floodplain inundation will result in enhanced primary productivity, an improved food web and flow of nutrients that better support a healthy and functioning ecosystem (Ahearn et al. 2006, Cloern et al. 2016). Floodplain inundation occurs when rivers or waterways exceed their channel capacity and flow onto adjacent lands. In the Delta, this most often occurs during winter and spring months.

Restoration of land-water connections to provide the biological benefits of floodplain inundation requires two components: 1) physical or hydraulic surface water connectivity for water to flow onto land; and 2) sufficient flow of water to inundate these connected areas (Merenlender and Matella 2013).

Connectivity

Surface water connectivity between areas of fresh and saline water, riverine, riparian, floodplain, and other aquatic and terrestrial transitions is critical for the health and productivity of aquatic ecosystems (Opperman 2012, SFEI-ASC 2014, Cloern et al. 2016, SFEI-ASC 2016). The aquatic food web benefits from an exchange between land and water habitats (Polis et al. 1997, Ahearn et al. 2006, Opperman et al. 2010). However, transformation of the Delta from its mid-1800s condition has also increased connectivity of some waterways in manners that may negatively affect ecosystem functions, such as through construction of water conveyance structures and channels that cross the Delta (Whipple et al. 2012). In some areas, limiting connectivity of waterways from such structures could improve ecosystem function (SFEI-ASC 2016). For example, closure of the Delta Cross Channel leaves additional flow in the mainstem Sacramento River and helps prevent entrainment of native fish species such as migration juvenile Chinook salmon.

The connectivity metric in this performance measure tracks the landscape in which physical dynamics, supported by geomorphic land-water interaction, can take place. This interaction requires two components: 1) physical or hydraulic connectivity that allows water to flow onto land; and 2) sufficient flow of water to inundate these connected areas (Merenlender and Matella 2013). Within the Delta, the terrestrial system has been largely disconnected from fluvial and tidal connectivity, even during periods of high flows. Restoring physical connectivity to the fluvial river and tidal system can help restore ecosystem processes and support many native species.

It should also be noted that hydrologic connectivity through surface waters can include more than floodplain areas. This is especially true in the Suisun Marsh and areas of the greater San Francisco Estuary. At this time this performance measure does not include areas such as riparian zones, because the focus is more on aquatic ecosystem functions in areas that can be inundated for extended periods and also due to limited habitat types within the Delta itself outside of floodplains or floodways. However, this could be explored further in the future, for example, by assessing the riparian area and upland transition zones, especially in Suisun Marsh (Goals Project 2015, Appendix E). While areas that function as riparian or intermittent floodplain are important, most of this habitat type is upstream or downstream of the Delta, where levees heavily constrain riparian function.

Inundation

Seasonal nontidal floodplain inundation is critical for providing a range of ecosystem benefits such as freeing and transformation of nutrients, increasing primary productivity, and creation of habitat that can serve as a migratory pathway, rearing habitat, and refuge for juvenile salmonids (Junk et al. 1989, Sommer et al. 2001b). Such areas promote wetland ecosystem functions and are a high-value area for rearing and spawning of fish species such as Sacramento splittail and Chinook salmon, leading to increased survival rates. Food production (phytoplankton and zooplankton biomass) requires sufficient duration of inundation to develop, thus food-web processes and habitat provision increase with duration of inundation (Sommer et al. 2001b, Moyle et al. 2008, Katz et al. 2017). Illustrative areas within or near the Delta include the Yolo Bypass, Sutter Bypass, agricultural and other vegetated lands that are regularly inundated, and areas of the Cosumnes River Preserve.

The hydrologically connected metric component tracks the area of land available to tidal and freshwater inundation, and the floodplain metric tracks nontidal, seasonal water surface area that inundates these connected areas.

Linkages to Delta Reform Act and the Coequal Goals

Delta Reform Act

The Delta Reform Act mandates that the Delta Plan include measures that promote specified characteristics of a healthy Delta ecosystem (Water Code section 85302(c)). Increased hydrologic connectivity and seasonal inundation of floodplains contribute to achieving "diverse and biologically appropriate habitats and ecosystem processes" (Water Code section 85302(c)(3)) and support "Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations" (Water Code section 85803(c)(5)).

Native resident and migratory fish species rely on habitat connectivity and floodplain inundation for their life cycle and the ecosystem functions they provide, aligning with "Viable populations of native and resident and migratory species" (Water Code section 85302(c)(1)). Restored land-water connectivity will provide diverse habitats and ecosystem processes such as primary production and energy transfer which supports "diverse and biologically appropriate habitats and ecosystem processes" (Water Code section 85302(c)(3)).

Delta Plan Core Strategy

4.2 Restore Ecosystem Function

Methods

Baseline Methods

Connectivity

Council staff developed a hydrologically connected spatial dataset by combining data for levee locations (to identify in-channel areas), bypasses, and floodways. Levee locations were compiled from multiple levee data sources, and from aerial imagery. Levee data sources included the following data sets. Data is listed in priority of use, with items first on the list being used in place of items later in the list when there is spatial overlap:

1. **DWR 2012:** i7 Delta Levee Centerline Classifications. Available online.
2. **URS 2007:** Delta Vision. Draft dataset provided by DWR and compiled by the consulting firm Arcadis in 2014 as part of the Council's Delta Levee Investment Strategy (DLIS) process. Not available online. DLIS feature class name: *DeltaVision_Levee_Reach_by_Hydro*
3. **DWR and URS 2007:** Delta Risk Management Strategy (DRMS) – Developed for DWR by URS Corporation in 2007; last updated 2013. Version used compiled by the consulting firm Arcadis in 2014 as part of the DLIS process. Not publicly available. DLIS feature class name: *levee_delta_centerlines_DRMS*
4. **Groves et al. 2019:** Decision Support Tool for the San Francisco Bay-Delta Levees Investment Strategy. Available online.
5. **DWR 2015:** Nonproject Levees. Part of a database intended to assist public agencies in assessing public safety needs for areas protected by levees. Compiled by the consulting firm Arcadis in 2014 as part of the DLIS process. Not publicly available. feature class name: *DWR_Levees_AllRDs*

Using the software program ArcGIS (version 10.4.1), these data were merged and clipped to the boundaries of the Delta and Suisun Marsh. Council staff removed areas when satellite imagery (NAIP 2016) indicated that the areas were unconnected, for example, when located on the landside of a levee. The connected areas were then compared to Global Surface Water Extent (GSWE) data to confirm if at least part of the contiguous area had been inundated at any point within the last 30 years. The baseline was then calculated as the entire hydrologically connected area, regardless of the area actually inundated during this period.

The hydrologically-connected area currently does not capture several tidal marsh areas. If and as restoration projects create newly connected tidal marsh areas in the future, these areas could be added in the future, and the entire layer updated.

Inundation

To calculate the baseline, the 1984-2018 GSWE data (Pekel et al. 2016) was used to identify areas that were inundated at least once every two years, but not inundated all of the time (i.e., inundation recurrence between 50 and 90 percent). The inundation dataset (GSWE, recurrence layer) was clipped to hydrologically connected surface areas within the Delta (Liberty Island was removed because it is now open water). For the baseline period for inundation, this analysis identified approximately 15,000 acres of inundated area matching these criteria. However, this represents a long-term average over more than 20 years. In addition, much of this area can be found within channel margins (bounded by levees) and along riparian areas/levee-water interfaces and is not limited to floodplains. Due to this and other limitations with the currently available data (see below), the baseline was set at approximately 15,000 acres as of the year 2018. This baseline date was selected to align with the period of data availability.

There are some limitations associated with the GSWE data. First, recurrence is calculated as a percentage of time that water appears at the same location from year to year. This means that an area could show 100 percent recurrence even if it is dry for periods of the year, and would be excluded by the less than 90 percent filter used in this analysis. Second, the GWSE appears not to include valid observations for the months of November, December, and January and this could affect the accuracy of the data. Third, there is no depth threshold for the inundation analysis since the data sources do not include this information.

Target Methods

Connectivity

The connectivity target is based on quantitative goals provided in the 2016 Central Valley Flood Protection Plan (CVFPP) Conservation Strategy, Appendix H (DWR 2016a, pp. H-4-6 to H-4-8) which identified numeric floodplain and tidal marsh area targets. These targets were based on the area modeled to help recover spring and fall-run Chinook salmon to meet the Central Valley Project Improvement Act (CVPIA) of 1992 salmon doubling goal. The area modeled to achieve this goal is reported in the 2016 CVFPP Conservation Strategy, Appendices H (DWR 2016a) and L (DWR 2016b) as follows: 11,000 acres for the Sacramento River Basin, and 4,500 acres for the lower San Joaquin River Basin. Analysis for the CVFPP identified that on average, only 17 percent of floodplains are considered suitable for salmonid species (DWR 2016a). To account for this, the areas required were divided by 17 percent to generate 64,705 acres needed for the Sacramento River Basin and 26,471 acres for the San Joaquin River Basin. Council staff then scaled these areas by the relative proportion of the Conservation Planning Areas (CPA) for the CVFPP within the Delta and Suisun Marsh as determined by a spatial analysis: approximately 52 percent of the Lower Sacramento CPA and 67 percent of the Lower San Joaquin CPA fall within this area. Multiplying by these respective factors (see equations below) results in 33,647 acres in the Lower Sacramento CPA and 17,735 acres in the Lower San Joaquin CPA, for a sum of 51,382 acres of floodplain habitat (see below). After rounding, the connectivity target is set to 51,000 acres. Here are the equations to set the targets:

- Sacramento CPA: 64,705 acres x 52% = 33,647 acres
- San Joaquin CPA: 26,471 acres x 67% = 17,735 acres

In addition to the connectivity approach described above, connectivity considerations are also illustrated in Appendix Q3, Figures 4-3 and 4-5.

Inundation

The 2016 CVFPP Conservation Strategy (Appendix H, p. H3-H7) calculated the amount of new floodplain needed in the Sacramento and San Joaquin watersheds to support doubling salmon populations, and it suggested that floodplains should be inundated in two-year intervals to support salmon life cycles (DWR 2016a). To calculate the area required for inundation targets, the connectivity target of 51,000 acres was proportionally split into nontidal (fluvial) and tidal areas based on estimation of historical habitats. San Francisco Estuary Institute’s (SFEI) historical ecology spatial data estimates 63 percent of the Delta as tidal, and 37 percent as nontidal (Whipple et al. 2012). Multiplying the nontidal estimate of 37 percent by the target of 51,000 acres of connectivity represents the floodplain inundation target of 19,000 acres (number rounded).

Data Sources

Primary Data Sources

The primary data sources listed below will be used for tracking this performance measure:

Connectivity

1. The Delta Stewardship Council Covered Actions Website. On-the-ground projects that restore surface water connectivity (such as levee breach, levee notch, weir modification, and tidal marsh restoration) are likely to meet the definition of a covered action and will need to establish consistency with the Delta Plan before implementation.
    a. Content: Covered actions' project description and supporting documentation provide details on project restoration activities and acres of land opened for hydrologic connectivity.
    b. Update Frequency: As covered actions are submitted and hydrologic connectivity is implemented.
2. San Francisco Estuary Institute (SFEI) Project Tracker. The Project Tracker is a tool that supports regional tracking of restoration projects and includes acres and locations of habitat types restored for hydrologic connectivity.
    a. Content: Project monitoring region wide.
    b. Update Frequency: As projects are implemented.

Inundation

1. GSWE from the European Commission Joint Research Center (JRC).
    a. Content: Global water surface areas (water extent, duration, and seasonality derived from remote sensing data).
    b. Update Frequency: Annually.

Alternative Data Sources

Alternative data sources will be used if the primary data sources become unavailable or are insufficient. Alternative data sources can be used concurrently with the primary data sources depending on best available science and the availability of the primary sources.

Connectivity

1. Two-dimensional hydrologic model and digital elevation model to identify the area that would physically allow fluvial or tidal surface water to flow onto land during events below the 1-in-100 recurrence interval flood flow, without pumping or modification of physical landforms. These areas may be dry in most conditions, but they could be hydrologically connected during high flows.

a. Content: Data to be developed based on two-dimensional hydrologic model (for example, SCHISM), high-resolution digital elevation model (based on 2017 or most up to date LiDAR-derived elevation).

b. Update Frequency: Updates are based on alternative methodology described above, when new elevation data or recurrence interval updates are available.

Inundation

1. Landsat Dynamic Surface Water Extent (DSWE) map. NASA makes available a Landsat-derived product that could be used to help monitor inundated surface water areas. Landsat satellite data has the longest historic record available and is anticipated to remain available far into the future with new satellite launches. However, because this is based on optical data it is affected by cloud cover and cloud shadow, making it less useful in winter months.

   a. Content: Estimate of surface water extent per pixel, derived from Landsat data and developed into interpreted layer of surface water extent.

   b. Update Frequency: Every 14 days; however, data may not be usable at this interval due to cloud cover.

2. National Aeronautics and Space Administration (NASA) and Indian Space Research Organisation (ISRO) Synethetic Aperature Radar (NiSAR) Mission. This mission will make active observations of surface water for at least three years, starting in early 2022. NiSAR data would help avoid an issue with the primary data source, where cloud cover affects imagery during periods of the year, limiting the ability to track inundation duration.

   a. Content: Data to be derived from imagery overlapping the Delta and Suisun Marsh.

   b. Update Frequency: Every 12 days.

3. European Space Agency SENTINEL Program. Sentinel-1 and Sentinel-2 platforms with combined overpass frequency of approximately every five days for a given location on Earth, including the Delta. Sentinel data would help avoid an issue with the primary data source, where cloud cover affects imagery during periods of the year. In addition, the update frequency of this dataset could allow for more accurate quantification of inundation duration. As part of this alternative, the duration of inundation (e.g., acre-days) could also be reported as supporting information.

   a. Content: Water surface extent, change, and seasonality derived from remote sensing data.

   b. Update Frequency: Approximately every five days. Sentinel water surface areas are anticipated to be incorporated into the base JRC GSWE data (Pekel 2019).

4. NASA Surface Water and Ocean Topography Mission (SWOT). Data from this mission should be available for at least three years after successful deployment and calibration, anticipated in 2022. The SWOT mission sensor includes the ability to measure water surface elevation. This means that it could be used to estimate water depth when used in conjunction with a known ground surface, such as LiDAR-derived terrain.
   a. Content: Water surface extent, elevation, change, and seasonality derived from remote sensing data.
   b. Update Frequency: Anticipate updates at a frequency equal to or better than 21 days.

Process

Data Collection and Analysis

Every year, Council staff will update the status of this performance measure by:

Connectivity

1. Reviewing Council Covered Actions website for projects that restore hydrologic connectivity (tidal marsh and floodplain restoration), and if necessary, contact project manager for clarifications on project status (construction status).
2. Adding project locations to the connected-land dataset and calculate acres open to hydrologic surface water connectivity.
3. Calculating annual change in hydrologically connected areas. Acres connected will be then calculated as the entire hydrologically connected area, regardless of the area actually inundated during this period.
4. If alternative or additional data sources are used, these sources will be disclosed on the Performance Measures Dashboard.

Inundation

1. GSWE data for surface water extent occurrence (primary data) will be downloaded in GeoTIFF format at~98 feet resolution (30 meters) in October of each year.

2. Data will be clipped to the boundaries of the Delta and Suisun Marsh, and converted to a projected coordinate system.
3. Council staff will analyze GSWE data primarily on the Google Earth Engine platform. Surface water area will be analyzed to determine maximum water extent during each water year (October 1 to September 31) for areas inundated 50-90 percent of the year.

Interim Performance Assessment

In order to provide a short-term assessment of progress toward the inundation and connectivity targets, intermediate milestones are set for evaluation every decade. The interim milestones are established on an assumed linear progression towards the 2050 target date:

Metric	Baseline (acres)	Total Area (Baseline Acres Plus Net Increase)		
		2030	2040	2050
Hydrologic Tidal and Fluvial Connectivity	75,000	92,000	109,000	126,000
Nontidal Inundation	15,000	21,400	27,700	34,000

Although linear progression is presumed for setting interim milestones, many management and environmental uncertainties exist, such as climate change and frequency of drought in implementing restoration projects and achieving the target acres of inundation and connectivity. Interim assessments of the performance measure will consider the existing state of the restoration in the Delta and disclose conditions impacting the rate of restoration interim progress.

Process Risks and Uncertainties

Assessments of the performance measure and the evaluation of interim milestones will account for issues within and outside of management actions and the long-term periods required to implement large-scale, on-the-ground projects.

Restoration of land-water connections to increase the areas with hydrologic connectivity that allow for increase in seasonal inundation depends on:

- Activities and effects within human management control (e.g., breaching or notching levees).
- Effects outside management control (e.g., peak flood flows, near- and medium-term sea level rise).

While areas outside of direct management control must be considered, the opportunities for reaching the target acreage require a concerted focus on modifications to the physical geometry of the Delta and Suisun Marsh.

Five-year averages will be used as interim milestones. However, a linear trajectory of annual acreage increases may not be a reasonable expectation. Rather, long lead times of restoration projects may cause a nonlinear increase in restored areas based on type and size of restoration projects completed.

Reporting

Reporting of this performance measure will include maps of connected areas and seasonally inundated areas, together with project locations that restore hydrologic surface water connectivity. Restoration project details will be displayed (e.g., year of restoration, type of connectivity restoration, acreages).

Every year, Council staff will report the status of this performance measure by:

1. Posting updates on the Performance Measures Dashboard.
2. Providing results in the Council's annual report (published in January).
3. Communicating management-relevant results at Council and Delta Plan Interagency Implementation Committee (DPIIC) public meetings.
4. Presenting findings at technical interagency groups, professional gatherings, and conferences.

Every five years, Council staff will assess and report the status of this performance measure by:

1. Communicating findings in the five-year review of the Delta Plan.
2. Informing the Council's adaptive management process and other decision-making.

Five-year averages will be used as interim milestones for assessments towards the target over the 30-year time period of 2020-2050 (i.e., every five years, to increase connected land by 8,500 acres and inundated areas by 3,000 acres).

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Performance Measure 4.16: Acres of Natural Communities Restored

Performance Measure (PM) Component Attributes

Type: Outcome Performance Measure

Description

Restoring large areas of natural communities to provide for habitat connectivity and crucial ecological processes, along with supporting viable populations of native species.

Expectations

Increase acres of natural communities to contribute to suitable habitat for fish and other wildlife, restored habitat connectivity, and viable populations of native species.

Metric

Acres of natural communities restored. This metric will be updated and evaluated every five years.

Baseline

Acres of natural communities from the 2007 Vegetation Classification and Mapping Program (VegCAMP) dataset by the California Department Fish and Wildlife (CDFW), as designated below:

Ecosystem Type	Baseline Acres (2007 VegCAMP)
Seasonal Wetland Wet Meadow Nontidal Wetland	5,100
Willow Riparian Scrub/Shrub Valley Foothill Riparian Willow Thicket	14,200
Tidal Wetland	19,900
Stabilized Interior Dune Vegetation	20
Oak Woodland	0
Grassland	33,000
Vernal Pool Complex	5,100
Alkali Seasonal Wetland Complex	700

Target

Net increase of target acres of natural communities by 2050:

Ecosystem Type	Target Acres Net Increase (from Baseline Acres)	Total Area (Baseline Acres Plus Net Increase)
Seasonal Wetland Wet Meadow Nontidal Wetland	19,000	24,100
Willow Riparian Scrub/Shrub Valley Foothill Riparian Willow Thicket	16,300	30,500
Tidal Wetland	32,500	52,400
Stabilized Interior Dune Vegetation	640	660
Oak Woodland	13,000	13,000
Grassland	No net loss	33,000
Vernal Pool Complex	670	5,770
Alkali Seasonal Wetland Complex	230	930

Basis for Selection

The wetland and riparian ecosystems of the Delta once supported productive food webs and rich arrays of native plant and animal species that contributed to exceptional biological diversity (Myers et al. 2000). Historically, the Delta and Suisun Marsh supported more than 650,000 acres of natural communities including riparian, wetland, and oak savanna. More than 90 percent of those ecosystems have been lost through reclamation and land conversion to agriculture and urban land uses (Bay Institute 1998, SFEI-ASC 2014). Reestablishment of some of these natural communities on the landscape—as the result of process-based restoration, improving ecosystem processes such as primary production and energy transfer—is a critical step in native species recovery. Natural community restoration will provide the physical space, connectivity, and habitat structure that species populations currently lack, as well as providing critical ecological functions such as aquatic primary production and vegetation community succession (Frermier et al. 2008, Golet et al. 2013). Multiple, interacting components of functional landscape will foster resilient and enduring restoration and management outcomes that benefit both people and wildlife (Wiens et al. 2016).

Recovery goals and biodiversity targets play a key role in translating ecological science and policy into on-the-ground action (Tear et al. 2005). Science-based objectives are often used to provide a unified understanding of conservation objectives among stakeholders and to make progress toward measurable goals (Dybala et al. 2017a, Dybala et al. 2017b). Recovery plans provide comprehensive guidance on the restoration and management of ecosystems based on the biology of the most threatened and endangered species (USFWS 2013).

Planning and management efforts, such as recovery plans, species-specific resiliency strategies, and conservation strategies identify specific actions for ecosystem preservation and restoration to meet species needs. Most of these efforts are focused on benefiting a single species or suite of similar species (e.g., riparian birds). Collectively, however, these plans provide valuable insight into the scale of ecosystem preservation, enhancement, and restoration necessary to benefit the multitude of species that rely upon the Delta ecosystem. At least 11 recovery and conservation plans exist which have geographic coverage in the Delta and Suisun Marsh (Council 2018). These plans identify restoration and management actions needed to achieve recovery of 35 species of special-status plants and 86 fish and wildlife species of conservation concern (Delta Plan, Appendix Q4). Nearly half of these species of conservation concern are endemic to the California floristic province, heightening the importance of recovering and conserving their populations in alignment with global conservation priorities (Wilson et al. 2006, Brum et al. 2017).

Restoration targets put forward by recovery and conservation plans are organized by the historical natural community types outlined in the Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process (Whipple et al. 2012). The historical natural community types are classified by plant community structure and physical characteristics such as hydrology and landscape position. Modern habitat types use the same classification by plant communities (SFEI-ASC 2014). Importantly, the natural communities described in both Whipple (2012) and SFEI-ASC (2014) are derived from VegCAMP, which uses the U.S. National Vegetation Classification System to organize species assemblages (Hickson and Keeler-Wolf 2007).

Restoration of complex ecosystems will require reestablishment of native vegetation communities and the underlying processes that support their recruitment, disturbance regimes, and community succession (Fremier et al. 2008, Golet et al. 2013). Restoring a variety of native vegetation cover types can promote ecological resilience and enhance native biodiversity by providing a range of habitat options for species, thus expanding the types and numbers of species that a landscape can support (SFEI-ASC 2014, DSC 2018). It can take many years for a restored habitat to establish, and the trajectory of natural communities' evolution is dependent on site-specific conditions and external factors (Zedler and Callaway 1999, Lowe et al. 2014). Post-project monitoring, habitat assessments and scientific studies about restoration trajectories will inform ecosystem restoration management (Golet et al. 2013).

Linkages to Delta Reform Act and the Coequal Goals

Delta Reform Act

Large areas of natural communities provide functional, diverse and interconnected habitat suitable for fish and other wildlife, and support recovery of native species. Achieving the target net increase in acres of the natural communities will provide diverse and functional habitats that support the following characteristics of a healthy Delta ecosystem:

- "Viable populations of native and resident and migratory species" (Water Code section 85302(c)(1)). Native resident and migratory species rely on natural habitats for their life cycle and the ecosystem functions they provide.
- "Diverse and biologically appropriate habitats and ecosystem processes" (Water Code section 85302(c)(3)). Reestablishment of large areas of natural communities provides for recovery of diverse habitats and ecosystem processes such as primary production and energy transfer.
- "Reduced threats and stresses on the Delta Ecosystem" (Water Code section 85302(c)(4)). Large areas of restored natural communities support the capacity of native species to respond to changing environmental conditions.
- "Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations" (Water Code section 85302(c)(5)). Target acres for riparian, seasonal wetland, and emergent tidal marsh support rearing habitat needs for juvenile salmon, contributing to recovery of naturally spawning salmon populations.

Delta Plan Core Strategy

4.2 Restore Ecosystem Function.

Methods

Baseline Methods

The acreage of natural communities was derived from CDFW VegCAMP (2007) and by referencing the associated ecosystem types described in the 2016 Central Valley Flood Protection Plan (CVFPP) Conservation Strategy (DWR 2016a) and SFEI-ASC (2014). The VegCAMP dataset maps vegetation in the Delta from field observations and high-resolution digital imagery, and classifies the vegetation based on the U.S. National Vegetation Classification Standard (http://usnvc.org). Vegetation classification (e.g., pickleweed, broadleaf-cattail) from the VegCAMP was referenced to ecosystem types (e.g., alkali seasonal wetland complex, valley foothill riparian) found in SFEI-ASC (2014, Appendix A, pages 102 – 105).

Target Methods

Targets for each natural community (ecosystem) type were derived from conservation and restoration targets identified in conservation and recovery plans within the Delta and Suisun Marsh (Delta Plan, Appendix Q4). These conservation and recovery plans include overlapping actions (e.g., the CVFPP Giant Garter Snake Recovery Plan and Tidal Marsh Recovery Plan include targets for the tidal wetland ecosystem).

The table below shows net increase of target acres by ecosystem type, and associated recovery and/or conservation plans with source references provided. Targets from recovery and conservation plans with geographically larger footprints, such as the CVFPP Conservation Strategy (DWR 2016a, DWR 2016b), were proportionally calculated for the Delta and Suisun Marsh region.

Net Increase of Target Acres and Associated Source References

Ecosystem Type	Target Acres Net Increase (Net Increase from Baseline Acres)	Source Reference (Recovery and Conservation Plans)
Seasonal Wetland Wet Meadow Nontidal Wetland	19,000	Central Valley Flood Protection Plan (DWR 2016b)
Willow Riparian Scrub/Shrub Valley Foothill Riparian Willow Thicket	16,300	Central Valley Joint Venture Implementation Plan (Dybala et al. 2017b)
Tidal Wetland	32,500	Central Valley Flood Protection Plan (DWR 2016a, 2016b); Central Valley Flood Protection Plan (CVFPP 2017b); Giant Garter Snake Recovery Plan (USFWS 2017); Tidal Marsh Recovery Plan (USFWS 2013); Suisun Marsh Habitat Management Plan (USBR, USFWS, CDFW 2013)
Stabilized Interior Dune Vegetation	640	A Delta Transformed (SFEI-ASC 2014)
Oak Woodland	13,000	Central Valley Joint Venture Implementation Plan (DiGaudio et al. 2017b)
Grassland	No net loss[1]	A Delta Transformed (SFEI-ASC 2014)
Vernal Pool Complex	670	Conservation Measure 9, Bay Delta Conservation Plan (DWR 2013)
Alkali Seasonal Wetland Complex	230	Conservation Measure 9, Bay Delta Conservation Plan (DWR 2013)

Note:

[1] Currently there are more grasslands than historically; most of which are within the interior Delta that used to be freshwater emergent wetland (Whipple et al. 2012). Grassland on the Delta perimeter provides more natural functions in support of native species. Although the target is no net loss, more grasslands in the Delta perimeter is the goal.

The conservation and restoration targets for seasonal wetland, wet meadow, nontidal wetland, and tidal wetland are based on quantitative goals in the CVFPP Conservation Strategy (DWR 2016a, Appendix H, pg. H-4-6 to H-4-8). The CVFPP identified numeric targets for Central Valley floodplain and tidal marsh. Tidal Marsh targets identified in Giant Garter Snake Recovery Plan (USFWS 2017), Tidal Marsh Recovery Plan (USFWS 2013), Suisun Marsh Habitat Management Plan (USBR, USFWS, CDFW 2013), and Fish Restoration Program Agreement (DWR and DFW 2010) are included within the cumulative 32,500 target from the CVFPP. These targets were identified based on the modeled estimate of rearing habitat area required to help recover spring and fall-run Chinook salmon to meet the 1992 Central Valley Project Improvement Act salmon doubling goal. These Central Valley numeric target values were proportionally calculated for the Delta and Suisun Marsh (52 percent of the Lower Sacramento Conservation Planning Area and 67 percent of the Lower San Joaquin Conservation Planning Area fall within the Delta). The conservation targets of the willow riparian scrub/shrub, valley foothill riparian, and oak woodland types are based on population and habitat objectives for avian conservation in the Delta region of the Central Valley Joint Venture (Dybala et al. 2017b). The willow riparian scrub/shrub and valley foothill riparian target of 16,300 was proportionally scaled for the Delta from the Central Valley (27.62 percent in Delta out of the total Central Valley acres).

Data Sources

Primary Data Sources

1. VegCAMP. Delta Vegetation and Land Use [ds292]. Biogeographic Information and Observation System (BIOS). California Department of Fish and Wildlife.
    a. Content: The VegCAMP data set has taxonomy for vegetation that is then assigned to appropriate habitat types in the Delta.
    b. Update Frequency: Every five years. First update toto the VegCAMP dataset was released in 2019.
2. VegCAMP. Vegetation - Suisun Marsh [ds2676]. Biogeographic Information and Observation System (BIOS). California Department of Fish and Wildlife.
    a. Content: 2015 Suisun Marsh vegetation map.
    b. Update Frequency: Every five years.

Alternative Data Sources

Alternative data sources will be used if the primary data sources become unavailable or are insufficient. Alternative data sources can be used concurrently with the primary data sources depending on best available science and the availability of the primary source.

1. San Francisco Estuary Institute (SFEI). Bay-Delta EcoAtlas. Geographic Information System of wetland habitats, past and present.
    a. Content: EcoAtlas Project Tracker is a mapping tool for restoration projects and provides access to acres of habitat types to be restored by a project (Project Tracker).

- Update Frequency: Frequency of restoration project updates varies. Council staff will review EcoAtlas at least every five years for restoration project updates.

Process

Data Collection and Analysis

Every five years, Council staff will update the status of this performance measure by:

1. Obtaining the updated VegCAMP datasets (Delta Vegetation and Land Use, Vegetation – Suisun Marsh).
2. Categorizing VegCAMP Associated Native Vegetation Community type (VegCAMP CaCode) into associated natural communities (ecosystem types).
3. Calculating total acres by each of the natural communities and calculating net increase over the five-year period and against the baseline.
4. Displaying maps of natural communities in the Delta and Suisun Marsh, and displaying change over five-year period and against baseline.
5. Method and results will be provided on the Performance Measures Dashboard.

VegCAMP updates follow a consistent vegetation mapping and classification methodology. A VegCAMP update based on the 2016 National Agricultural Imagery Program dataset was completed in November 2019.

Interim Performance Assessment

In order to provide a short-term assessment of progress toward the restoration targets in this PM, intermediate milestones are set for evaluation every decade. The interim milestones below are established on an assumed linear progression toward the 2050 target date, and can be calculated as five-year averages (for example: the five-year average net increase for tidal wetland is about 5,500 acres), or ten-year averages:

Ecosystem Type	Baseline	Target Area (Baseline Acres Plus Net Increase)		
		2030	2040	2050
Seasonal Wetland Wet Meadow Nontidal Wetland	5,100	11,400	17,700	24,100
Willow Riparian Scrub/Shrub Valley Foothill Riparian Willow Thicket	14,200	19,600	25,100	30,500
Tidal Wetland	19,900	30,800	41,600	52,400
Stabilized Interior Dune Vegetation	20	240	450	660
Oak Woodland	0	4,400	8,700	13,000
Grassland	33,000	33,000	33,000	33,000
Vernal Pool Complex	5,100	5,300	5,500	5,700
Alkali Seasonal Wetland Complex	700	780	860	930

Although linear progression is assumed for setting interim milestones, many management and scientific uncertainties exist in implementing restoration projects and achieving the target acres of desired natural communities. Interim assessments of the performance measure will consider the existing state of restoration in the Delta and disclose conditions impacting the rate of restoration interim progress.

Existing efforts and tools evaluating restoration effectiveness and natural communities' conditions will be considered in interpreting this performance measure. These may include: Wetland Regional Monitoring Program (WRMP) and Habitat Development Curves for wetland and aquatic resources, Tidal Wetland Monitoring Framework for the Upper San Francisco Estuary for fisheries benefits, and project-specific long-term monitoring and operations plans.

Process Risks and Uncertainties

A linear increase in the net acres of natural communities may not be a reasonable expectation. Rather, longer-term restoration projects may cause nonlinear increase in restored areas based on type and size of restoration action completed. In addition, changes in natural communities in response to restoration actions may be nonlinear, discontinuous, abrupt, and have multiple trajectories. Scientific advances, emerging tools, effectiveness monitoring, and long-term monitoring of restoration areas will inform adaptive management of ecosystem restoration.

The Delta is subject to sea level rise, subsidence, and urbanization, all of which can constrain where and how much ecosystem restoration can be implemented compared to other conservation actions. It is uncertain whether restoration will be able to outpace sea level rise and rising temperatures associated with climate change.

Reporting

Every five years, Council staff will assess and report the status of this performance measure by:

1. Posting updates on the Performance Measures Dashboard.
2. Providing results in the Council's annual report (published in January).
3. Communicating findings in the five-year review of the Delta Plan.
4. Informing Council's adaptive management and other decision-making.
5. Communicating management-relevant results at Council and Delta Plan Interagency Implementation Committee (DPIIC) public meetings.
6. Presenting findings at technical interagency groups, professional gatherings, and conferences.

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Appendix C
Attachment C-4.5
Non-substantive Revisions to Data Sheets for New and Refined Performance Measures

Appendix C
Attachment C-4.5

Non-substantive Revisions to Datasheets for New and Refined Performance Measures

Performance Measure 4.6 Datasheet

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Along with adult numbers returning to spawn, a critical component to increasing natural production is natural-origin juvenile abundances and survival through the Delta, Bay, and into the ocean. For productivity to increase, the number of returning adults produced per parent spawner must exceed one, as estimated in stock-recruitment curves (Dahm et al. 2019). However, juvenile survival rate in various Delta habitats is not well documented, and further studies are needed to better understand the effect of restored habitat on juvenile survival. In order to address this gap, revised Delta Plan Ecosystem Restoration Recommendation 9 (ER R9) recommends increased coordination among researchers studying juvenile anadromous fish migration pathways and survival upstream of, and within the Delta waterways to improve synthesis of results across research efforts and application to adaptive management actions.

Estimating the number of juveniles migrating downstream is required to establish stock-recruitment relationships that help estimate how management actions and changing environmental conditions impact the ratio of spawners to progeny. Rotary screw traps are typically used to estimate the abundances of migrating juvenile populations, but these programs need large sample sizes to make reliable population estimates (Dahm et al. 2019). Other challenges in gathering juvenile salmon data include misinterpreting run types since juveniles from different runs may be migrating downstream at the same time. Compared to adults, determining attributes (hatchery vs. natural-origin, age, size, release location, etc.) of migrating juveniles is more difficult because internally inserted coded wire tags that contain the information can only be acquired from carcasses. More complexities arrive since various juvenile life history stages likely contribute differently to adult returns.