Supporting Documentation and Scientific Information for Suisun Marsh Individual Ownership Adaptive Habitat Management Plans

(Revised: August 2021)

Suisun Resource Conservation District

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C. Overview

C.1 Suisun Marsh Background

Suisun Marsh (the Marsh) is one of the largest remaining contiguous brackish marshes in the United States, located about 35 miles northeast of San Francisco in southern Solano County (Kwasny et al. 2004). Brackish water refers to wetlands with salinities between 1.56 – 31.3 mS/cm[1] electrical conductivity (SRCD 1980) or about 0.5-18 ppt. There are few wetland ecosystems in North America that have been more heavily modified than those in California. Massive flood control, water storage, and water conveyance projects have altered the natural hydrology that once supported over 4 million acres of wetlands in the Central Valley (CVHJV 1990). Today, most of the remaining 5% of historic wetlands in the Central Valley require intensive management, including “artificial” flooding. Now, the task of wetland managers is to emulate natural wet and dry cycles and recreate a dynamic and productive wetland system through varied flooding regimes and periodic vegetation control.

Figure 9. Harvesting asparagus on muck and peat land, Grizzly Island 1930.

Suisun Marsh represents over 10% of all remaining natural marshland in California and provides habitat for numerous species of plants, fish, and wildlife. As part of the Pacific Flyway, the Marsh hosts thousands of resident and migratory waterbirds every year. Historically, the Marsh was comprised of a wide plain of saltgrass (*Distichlis spicata*) associations supporting large numbers of brackish (halophytic) marsh plant species and included about 68,000 acres of tidal wetlands. Most of the region’s levee and water control infrastructure were used for agriculture **(Figure 9)** and waterfowl hunting clubs; however, since the turn of the 20th century, they have been used to create seasonal wetland habitat. Today, 90% of the wetlands in the Marsh are diked seasonal wetlands and managed to provide food, cover, and nesting habitat for wildlife, and are referred to as managed wetlands. Managed wetlands are defined as leveed areas within the primary management area in which water inflow and outflow is artificially controlled, or in which waterfowl food plants are cultivated, or both, to enhance habitat conditions for waterfowl and other water-associated birds and wildlife (SRCD 1980). The diked managed wetlands in the Marsh flood and drain from tidal sloughs and bays and receive direct rainfall in the winter. Furthermore, daily Central Valley river inputs, along with meteorological forces including wind, barometric pressure change, and evaporation, all significantly influence the Marsh.

In 1963, the Suisun Soil Conservation District was formed and later renamed the Suisun Resource Conservation District. The Suisun Resource Conservation District (SRCD) encompasses the wetland, upland, and open water areas of the Marsh. It includes 52,000 acres of diked managed wetlands, 27,000 acres of uplands, 6,300 acres of tidal wetlands, and 30,000 acres of bays and sloughs, all protected by the Suisun Marsh Preservation Act (SMPA 1977) of 1977. SRCD has the primary local responsibility of regulating and improving water management practices on privately owned lands within the primary management areas of the Marsh. The diked wetlands and most of the upland areas are managed for desirable waterfowl food, crop cover, and nesting habitat for resident and migratory wildlife. Seasonal wetland management strategies in the Marsh are primarily based on waterfowl food habits studies conducted in the Marsh during the late 1960s and early 1970s (Rollins 1981). These studies concluded that plant communities in the Marsh are controlled primarily by the depth and duration of soil submergence and secondarily by the concentration of salts in the root zone. The complexity (including water salinity, soil salinity, tides, and water delivery schedules) of this system requires managers to pursue and create conditions favorable for numerous birds, mammals, and plant species.

C.1.1 Relevant Protection Policies and Laws

In the late 1960s, the Director of the Suisun Soil Conservation District recognized the threat to the natural resources of the Marsh by pressures of increasing urbanization and development in Solano County. Due to these pressures, in 1973, SRCD worked with the California Department of Fish and Wildlife (DFW) to sponsor legislation that would define a buffer zone around the primary management area and preclude any development within this area until a long-range protection plan was created by DFW and the San Francisco Bay Area Conservation Development Commission (BCDC). In 1974, the Suisun Marsh landowners requested and supported the passage of the Nejedly-Bagley-Z'berg Suisun Marsh Preservation Act (SMPA 1974), to protect the Marsh from potential commercial, residential, and industrial developments. The act directed BCDC and DFW to create the Suisun Marsh Protection Plan (SMPP) with the goal to preserve the integrity and assure continued wildlife use of the Marsh. In preparation for the SMPP, DFW cataloged the ecological characteristics of the Suisun Marsh and its surroundings and established a recommended natural resource protection plan

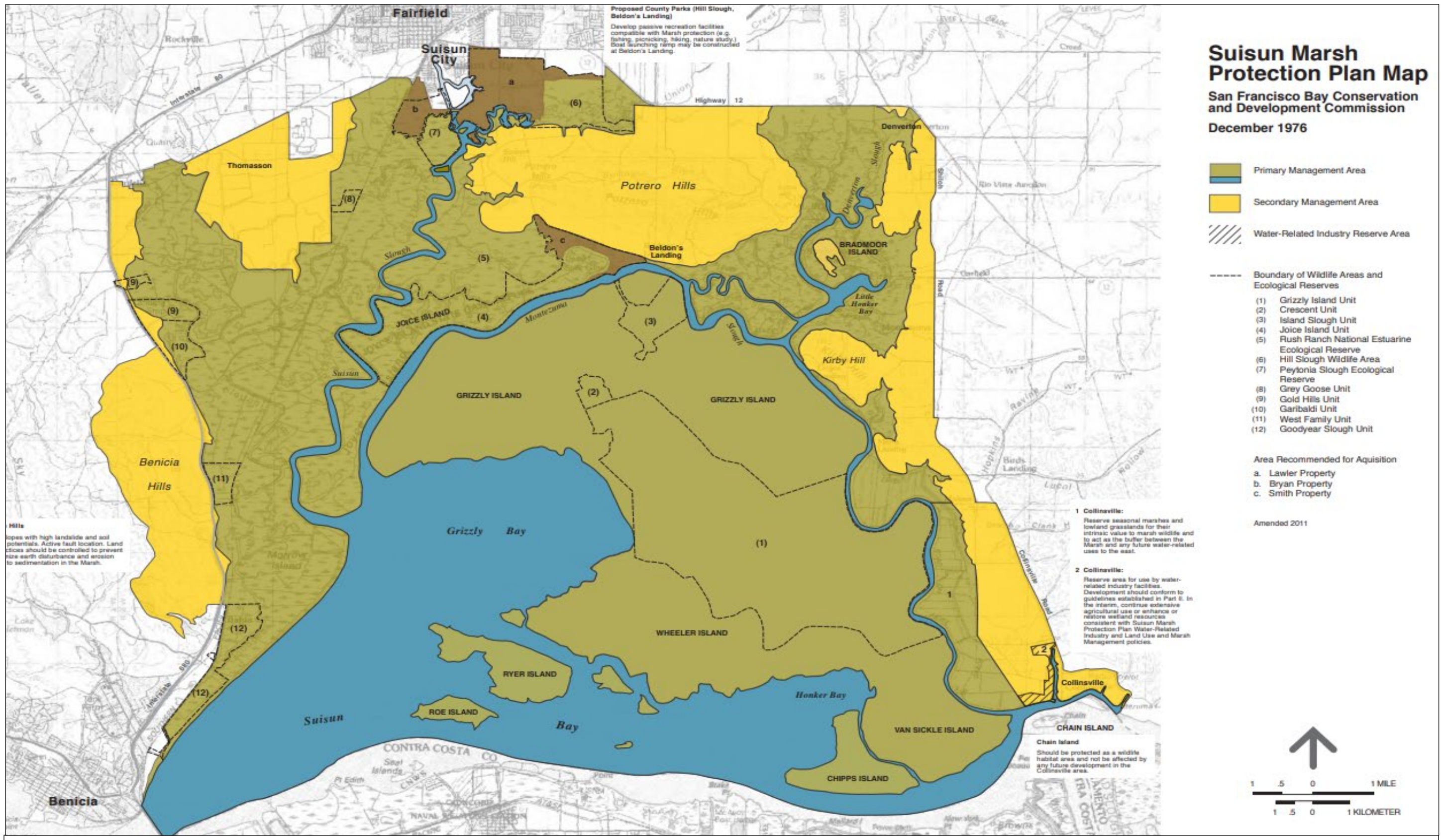


Figure 10. Suisun Marsh map. Primary and secondary management areas (BCDC 1976).

which later became the final SMPP in 1976. Once completed, the SMPP was formerly adopted as part of the Suisun Marsh Preservation Act of 1977 (SMPA 1977). The main goal of the SMPP was to preserve, protect, enhance, and restore Suisun Marsh resources. The SMPP established land use policies for the Marsh along with establishing the primary and secondary boundaries, and it designated regulatory responsibilities to BCDC and Solano County (**Figure 10**). Legislative requirements of the 1977 SMPA and the 1978 State Water Quality Control Plan Water Rights Decision 1485 established the Marsh salinity standards. In addition, the Department of Water Resources (DWR) and United States Bureau of Reclamation (USBR) required creation of the 1984 Plan of Protection for the Marsh, including an Environmental Impact Report (DWR 2017).

With passage of the SMPA in 1977, local governments and special districts with responsibility or jurisdiction over the Marsh were required to create a Local Protection Program (LPP). The LPP outlines policies, ordinances, and regulations to guide land uses to the following agencies: Solano County, City of Fairfield, Solano County Mosquito Abatement District (SCMAD), Solano County Local Agency Formation Commission (LAFCO), City of Benicia, Suisun City, and SRCD for operations within and adjacent to the Marsh (SRCD 1980). A major component of the Suisun Marsh Management Program (SMMP) requires SRCD to include a water management program for each managed wetland in private ownership within the boundaries of the primary management area of the Marsh. The water management programs have to be reviewed by the DFW and certified by BCDC. The objectives and scope of these water management programs reflect on the policies and provisions of the Suisun Marsh Protection Plan (Section 29412.5 Public Resource Code) and resulted in the initial duck club management plans in the 1980s.

Each privately managed wetland ownership within the Primary Management Area of the Marsh is managed in conformity with the provisions and recommendations of the individual management plans for that ownership as approved by SRCD, DFW, and BCDC (SRCD 1980). It is the responsibility of the landowner on record to comply with the provisions and recommendations of the certified management program and any change in landownership will fall on the new landowner who assumes this responsibility. Proposals for modifications of certified programs are submitted by the landowners to SRCD. SRCD will treat proposals as amendments to its component of the LPP (SRCD 1980). Annually, SRCD will make a report to BCDC's Executive Director of any minor amendments to any certified individual management plans (PRC Section 29418). Minor repairs or improvements are defined as those activities which are routine in management of wetland systems. Such activities as reconstruction, replacement, removal, repairs, and incidental additions should be considered minor. Any management activity currently described in the certified duck club management plan and its appendices will be considered minor and shall not require a BCDC Marsh Development Permit (MDP) or an amendment to the certified Plan. All private landowners within the Primary Management Area also must comply with the regulations of the Bay Area Air Quality Management District (BAAQMD) with respect to burning of marsh vegetation within the Primary Management Area.

The Suisun Marsh Habitat Management, Preservation, and Restoration Plan (SMP) Environmental Impact Report (EIR) was completed in 2011(SMP EIR 2011) and the companion Environmental Impact Statement (EIS) was completed with a record of decision in 2014 (SMP EIS 2014). This SMP allowed the Suisun Marsh principal agencies to meet the needs of the Suisun Marsh Preservation Agreement (SMPA 1987). The SMP is a 30-year plan designed to address the various conflicts regarding the use of the Marsh resources, the approach of restoration in tidal wetlands, and the management of managed wetlands and their important functions (DWR 2017). The SMP also sets the foundation for operations of managed wetlands including private and public land use, habitat restoration, levee system integrity, and water quality (DWR 2017).

C.1.2 Suisun Marsh Principal Agencies

The Marsh is governed and operated by local, State, and Federal agencies and regulations that work towards a common goal of protecting and enhancing the Marsh. The following agencies are included:

Suisun Resource Conservation District (SRCD): A Special District of the State of California, SRCD represents private landowners in the Marsh with a mission to achieve water supplies of adequate quality and promoting preferred habitats that support wetland resource values through best management practices. It has the primary local responsibility to regulate and improve water management practices on privately owned lands within the primary management area of the Marsh (Public Resource Code 9962). https://suisunrcd.org/

Permitting agencies:

California Department of Fish and Wildlife (DFW): Manages California's diverse fish, wildlife, and plant resources and the habitats upon which they depend for their ecological values and for their use and enjoyment by the public. Largest landowner in the Marsh, manages the 15,000-acre Grizzly Island Wildlife Area (GIWA) Complex. https://www.wildlife.ca.gov/

Delta Stewardship Council (DSC): rovides the best possible scientific information for water and environmental decision-making in the Bay-Delta system, and develops scientific information and synthesis on issues critical for managing the Bay-Delta system. http://www.deltacouncil.ca.gov/

National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) formerly known as National Marine Fisheries Service (NMFS): Evaluates impacts on fish and wildlife of all new permitting projects to meet requirements in Section 404 of the Clean Water Act. Under Section 7 of the Endangered Species Act (ESA), federal agencies must consult with NOAA Fisheries on activities that may affect the ESA-listed species. Issues Biological Opinions (BOs) on actions that may affect ESA-listed species and critical habitat including a Biological Opinion for Suisun Marsh. https://www.fisheries.noaa.gov/

San Francisco Bay Conservation and Development Commission (BCDC): Protects and enhances San Francisco Bay and encourages the Bay's responsible and productive use for this and future generations. BCDC and the DFW were responsible for writing the Suisun Marsh Protection Plan, and BCDC issues permits for projects and maintenance activities in the Marsh. http://www.bcdc.ca.gov/

San Francisco Bay Regional Water Quality Control Board (RWQCB): Preserves, enhances, and restores the quality of California's water resources. Regulates discharges of fill and dredged material under the Clean Water Act Section 401. https://www.waterboards.ca.gov/sanfranciscobay/index.html

U.S. Army Corps of Engineers (USACE): Administers day-to-day programs, including individual and general permit decisions, most Suisun Marsh lands are regulated under Regional General Permit 3 (RGP 3) managed by SRCD; conducts or verifies jurisdictional determinations; develops policy and guidance; and enforces section 404 permit provisions of the Clean Water Act. Protects and preserves the waters of the U.S., regulates construction in navigable waters, and placement of fill in wetlands. In accordance with the Clean Water Act section 404, the USACE administers construction permits for filling, grading, land clearing, ditching, and piling installation in the waters of the U.S. (USACE 404 Section 10). https://www.spn.usace.army.mil/

U. S. Fish and Wildlife Service (USFWS): Works with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continued benefit of the American people. Evaluates impacts on fish and wildlife of all new permitting projects to meet requirements in Section 404 of the Clean Water Act. Under Section 7 of the Endangered Species Act (ESA), federal agencies must consult with USFWS on activities that may affect the ESA-listed species. Issues Biological Opinions (BOs) on actions that may affect ESA-listed species and critical habitat. https://www.fws.gov/

Principal Agencies:

Department of Water Resources (DWR): sustainably manages the water resources of California in cooperation with other agencies to benefit the state's people and protect, restore, and enhance the natural and human environments. DWR mitigates its impact on the Marsh from the operation of the State Water Project, where feasible, the enhancement of fish and wildlife (Water Code Section 119000). DWR maintains and operates water conveyance and delivery facilities, the Suisun Marsh Salinity Control Gates, and water quality monitoring stations and wetland mitigation site in the Marsh. https://water.ca.gov/

U.S. Bureau of Reclamation (USBR): Largest wholesaler of water in the country, manages and protects water and related resources in an environmentally and economically sound manner in the interest of the American public. https://www.usbr.gov/

Conservation Partners:

California Waterfowl Association (CWA): Seeks to grow California's waterfowl populations, wetlands, and hunter-conservationist communities. https://www.calwaterfowl.org/

Ducks Unlimited (DU): Conserves, restores, and manages wetlands and associated habitats for North America's waterfowl. These habitats also benefit other wildlife and people. https://www.ducks.org/

Solano Land Trust (SLT): Protects land to ensure a healthy environment, keeps ranching and farming families on their properties, and inspires a love of the land. https://solanolandtrust.org/

U.S. Geological Survey (USGS): Serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. https://www.usgs.gov/

C.2 Managed Wetlands

Managed wetlands are defined as leveed areas within the Primary Management Area of the Marsh in which water inflow and outflow is artificially controlled, or in which waterfowl food plants are cultivated, or both, to enhance habitat conditions for waterfowl and other water associated birds and wildlife (SRCD 1980). Wetland management involves diversion and subsequent draining of tidal waters into and out of managed wetlands which are separated from bays and tidal sloughs by exterior levees. Interior levees separate adjacent managed wetlands and deliver water to the individual managed wetlands units through water control structures. Public and private landowners use various structures such as levees, ditches, water control facilities, pumps, and fish screens to manipulate the timing, duration, and depth of flooding to meet wetland management objectives.

The primary tools used in managed wetlands to create a mosaic wetland habitat for waterfowl include water management, burning, discing, mowing, and other actions to manipulate and enhance vegetation growth. Draining wetlands to "bone dry" conditions promotes seed gemination and plant growth in moist-soil management. The managed wetland cycle includes a summer period (dry period), a fall flood up period (wet period), and a spring leach cycle period (Baginska 2012). During the dry period, the wetlands are drained to allow for annual maintenance including discing, moving, invasive weed treatments, and vegetation planting.

During the wet period, wetlands are flooded which decomposes vegetation and provides habitat for wintering and migrating waterfowl, shorebirds, and other wildlife (**Figure 11**).

The operations schedule for managed wetlands are driven by several factors including: water year type (wet season vs. dry season), location within the Marsh, weather conditions, diversion restrictions on unscreened diversions, and water control facilities. Most wetland managers begin flooding their wetlands in late September and early October in preparation for the fall waterfowl migration.

Since most managed wetlands are at or below mean tide in elevation, gravity flow can be used to fill and drain the wetlands. The wetlands are filled during flood (incoming) tides, when the water can flow easily through the open water control structures into the managed wetlands. Wetlands are drained during ebb (outgoing) tides when water can flow out of the control structures by gravity into the sloughs and bays. In order to allow the managed wetlands to fill to an average depth of 8-12 inches, the inlet gates are opened and drain gates are closed during initial flood-up. During the two high tide cycles within a 24-hour period, water diversions may operate for less than 12 hours a day to flood a wetland. The volume and velocity of water diversions in the wetlands vary greatly based on the location and diameter of the intake control structure and the head pressure created by the high-tide stage.

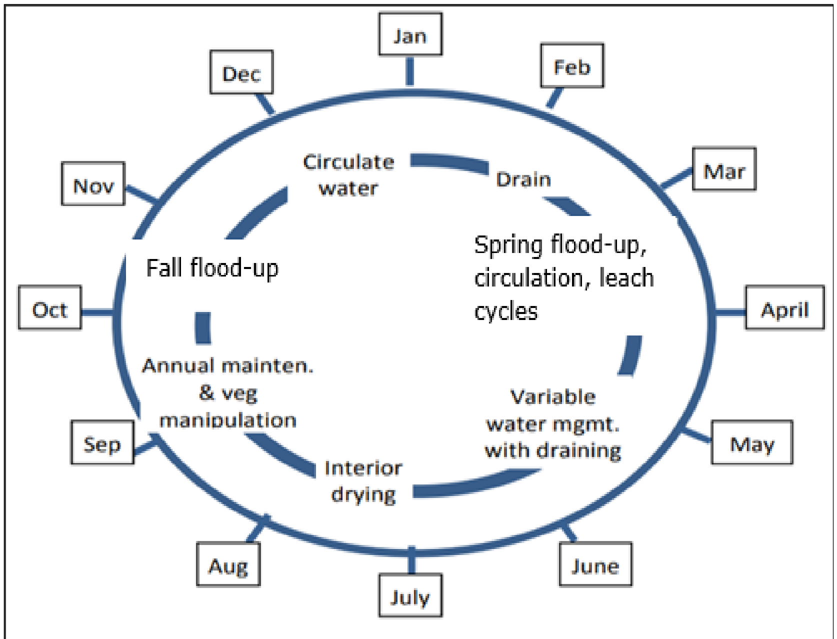


Figure 11. Conceptual representation of the typical water management cycle of a managed wetland (Baginska 2012).

After the initial fall flood-up, water is circulated through managed wetlands in mid-October to late January to maintain water quality and appropriate water depth for wintering waterfowl. Compared to the initial flood-up period, relatively small amounts of water are exchanged between the sloughs and the wetlands during circulation. If conditions of poor water quality or high mosquito production occur, increased circulation or complete drainage may be required on the managed wetlands during the month of October.

Following waterfowl season, spring leach cycles are performed in the managed wetlands (February-May) to irrigate wetland vegetation and reduce salinities within the managed wetlands. Higher Delta outflow, spring weather, lower salinities and drainage capabilities influence when wetland units can be drained and be re-flooded. To remove salts from the wetlands, managed wetlands undergo 1-3 leach cycles per year consisting of rapid draining and re-flooding with lower salinity water to about half of the autumn water levels. Once these leach cycles are complete, water is diverted to maintain an adequate level and to meet water quality standards. Water remains in the managed wetlands through June-July and is then drained to allow for vegetative growth and routine maintenance activities during the summer work season.

The Marsh serves as a resting and feeding ground for millions of waterfowl migrating on the Pacific Flyway and provides essential habitat for >221 bird species, 45 mammal species, and >40 fish species including several endangered species. The Marsh is critical to the survival of wintering migratory birds on the Pacific Flyway, particularly during drought conditions, and represents a unique resource for a wide range of aquatic and wildlife species (Baginska 2012). The managed wetlands within the Marsh are currently maintained as private waterfowl hunting clubs and as refuges on publicly owned wildlife management areas. Managed wetlands provide a crucial habitat of migration corridors and provide extensive cover for nesting and foraging opportunities for wintering mammals, waterbirds, shorebirds, raptors, fish, and amphibian species (BCDC 1976). Managed wetlands can protect upland areas by retaining flood waters and provide an opportunity for needed space for adjacent wetlands to migrate landward as sea level rises (BCDC 1976).

C.2.1 Managed Wetland Operations - Conceptual Model

The managed wetland conceptual model provides a general description of the existing conditions and operations on managed wetlands in the Marsh (**Figure 12**). The model is a guide to help landowners understand how managed wetlands work and how to best manage these complex systems. Marsh management and the water control facilities that manipulate the timing, duration, and depth of flooding play a significant role in determining wetland plant communities (DWR 2001). Wetland managers use various structures such as levees, ditches, water control structures, controllable topography, pumps, and screens to meet management objectives (Barthman-Thompson et al. 2007).

Since existing conditions change continually, the conceptual model only serves as a starting point for managed wetland actions. The model describes physical and biological conditions and the ways these conditions affect the management of wetlands (**Figure 13**). It also describes the regulatory constraints on habitat management and water intake restrictions in addition to strategies used to operate managed wetlands within those restrictions (**Appendix N).**

C.2.1.1 Managed Wetland Infrastructure Standards

The majority of the Marsh is at or below the mean tide elevation. Levees serve as the primary function of flood control and habitat protection (Goude et al. 2005). There are two types of levees within the Marsh, exterior and interior. Both types of levees are used in conjunction with ditches and water control structures to manage the diked wetlands. Most exterior levees were initially constructed for agriculture or to protect managed wetlands, state lands, and residences from uncontrolled tidal inundation and flooding (Goude et al. 2005). Presently, exterior levees are primarily embankments that prevent uncontrolled flooding of marshland from tidal action. They allow for the management of water to flow inside and outside of managed wetlands. The standard height for the crown of the exterior levee is 9 feet above zero tide with a minimum of a 12-foot top width **(Figure 14).**

The exterior levees in the Marsh present special maintenance problems due to their exposure to wind generated wave action and tidal erosion, the potential of levee failure on one ownership affecting contiguous inland ownerships. Increased salinities from decreased Delta outflow can negatively impact and decrease tule berms that protect many of the managed wetlands exterior levees and can increase the cost of maintaining levees.

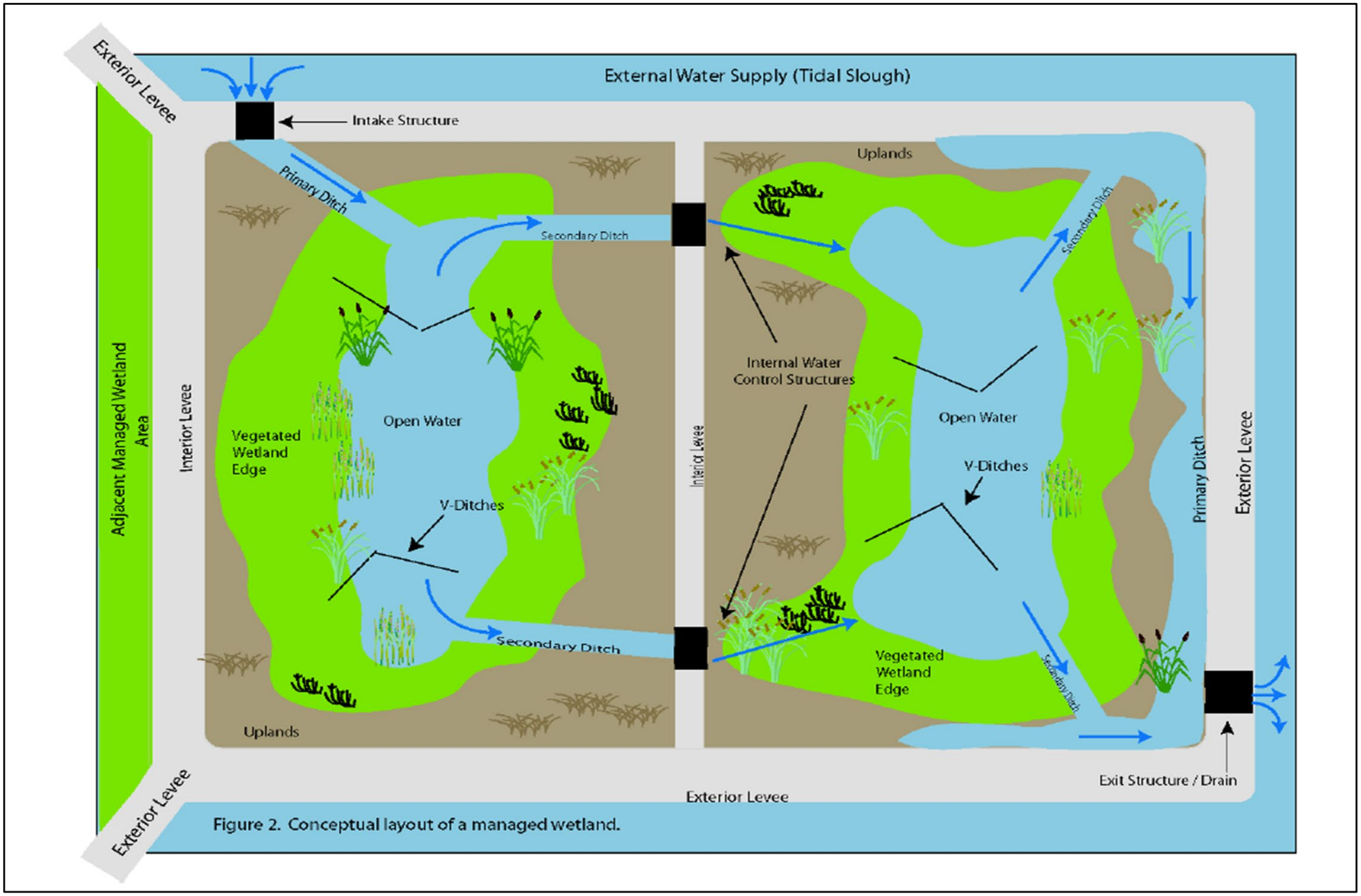


Figure 12. Conceptual layout of managed wetland (Barthman-Thompson et al. 2007).

Figure 13. Simple model of driving forces in a managed wetland system (Barthman-Thompson et al. 2007)

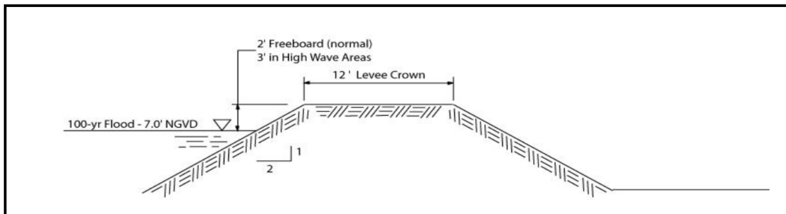


Figure 14. Standard Suisun Marsh Exterior Levee Section

Levees need routine repair and maintenance which typically includes restoring levee contours, levee resurfacing, repair of gates and hydraulic structures, mowing vegetation, discing levee soils, and embankment repairs. Typical causes of levee maintenance problems include storm events, levee subsidence, wave action, and rodent damage (DWR 2001). Levees are primarily maintained by private landowners, local Reclamation Districts, or public agencies (CDFW). There is currently no state or federal funding for a majority of the levee maintenance expenses in the Marsh. The minimum standards for levee repair and maintenance include the following: both exterior and interior levee contours must be restored to match previously existing levee cross sections; if the existing side slope is eroding beyond 1.5-foot rise to a 1-foot run it needs to be restored, the slope shall be rebuilt to 2-foot rise to 1-foot run; and coring shall be done only to repair damage from animal channels or to eliminate seepage (SRCD 1980; **Appendix I**).

Interior levees are embankments which allow for management of water inside exterior levees on the managed wetlands. They are not exposed to tidal action like the exterior levees, instead they isolate specific areas within the managed wetland to provide areas of independent water control. The standards for interior levees include a crown of <4 feet above pond bottom and a top width of 10 feet.

Water control structures are used in conjunction with interior and exterior levees and ditches to control the application and drainage of water on a managed wetland. A water control structure consists of the combination of a pipe and component parts attached to the ends of a pipe, depending on the pipe's intended purpose. Water control structures distribute and remove water from the managed wetlands at the discretion of the water manager (**Figure 15**). These structures should be adequate in size, number, type, and location to permit flooding and draining of a managed wetland within a 30-day period (Rollins 1981). There are three primary types of exterior water control structures in the Marsh: flood, drain, and dual-purpose structures (**Appendix J**).

Figure 15. Water control structure slide gate.

A flood structure is used to divert water during high tide from an adjacent tidal slough into a managed wetland unit. The pipe diversions can range from 12-48 inches in diameter and are typically fitted with screw gates or screw flaps on the tidal side of the exterior levee. Based upon the elevation of the structure in the exterior levee, the interior side of the pipe is typically an open pipe or a flap gate to prevent the back flow of water during low tide. Flooding structures are typically located near the high pond bottom areas of a managed wetland unit. This allows water to flow toward the low areas of the ponds, creating circulation and effective conveyance of water to the drainage structures.

The primary water control gate structures include: flap gates, screw-flap gates, screw gates, and flashboard risers or weirs. A *flap gate* is a hinged metal cover installed on the end of a culvert designed to allow free water flow in one direction, while preventing back flow from the other direction. The size of the opening on a flap gate is controlled by the water pressure against the flap. A *lift flap gate* is like a flap gate, but has a winch or chain added to permit mechanical lifting of the flap and allowing a controlled amount of water backflow to occur. A *screw gate* is a metal cover which slides up and down in a frame attached to the end of a culvert. It is raised and lowered by a screw mechanism which is usually turned by hand. With the screw gate, water flow is equal in both directions and water volume is determined by the degree of the opening.

A *screw/flap gate (combo gate)* is comparable to a screw gate, but with a flap gate added to prevent back flow. Combo gates are commonly used when gates must serve as a dual function as an inlet and outlet of water. A *flashboard riser* or *weir box* is a plastic or metal structure placed vertically on the inlet or outlet side of a pipe with vertical grooved runs for inserting horizontal planks. The planks (boards) are placed one on top of the other to reach the desired water height. Any excess water above the height of the boards will overflow out through the flashboard riser. The boards can be removed for complete water drainage. (Barthman-Thompson et al. 2007).

In addition to water control structures, culverts and ditches help direct water throughout managed wetlands. A *culvert* is a pipe placed in a ditch to allow access or a ditch crossing, while still conveying water to the managed wetland. The Marsh has three different types of ditches: primary, secondary, and swales. Primary ditches (also called main, supply, and circulation ditches) create a network of aqueducts which start and end at exterior levees (Rollins 1981). The primary ditch system is used to drain a managed pond within a 30-day period (SMMP 1980). Primary ditches also transport water to and from a major water source to flood, circulate, and drain managed wetlands. The main purpose of a primary ditch is to deliver water from intake structures located in the exterior levees to ponds, or to remove water from ponds to outlet structures located in the exterior levees. The ditches should be large enough (12-20 feet wide) to flood the entire managed wetland within 10 days, drain the entire managed wetland within 20 days, and deep enough (3-3.5 feet deep from pond bottom) to drain secondary ditches to increase the effectiveness of leach cycles (SRCD 1980). Design criteria of a primary ditch is minimum width of 2 feet, depth of 2 feet below natural ground level, and side slope of 1.5:1 or more (**Figure 16**).

Secondary ditches are found on larger properties and supply water to flood ponds on managed wetlands within 10 days, drain within 20 days, and are typically 6-10 feet wide and 2-2.5 feet deep (**Figure 17**). Secondary ditches connect swales to primary ditches and empty out to the water control structure**.** Due to the high

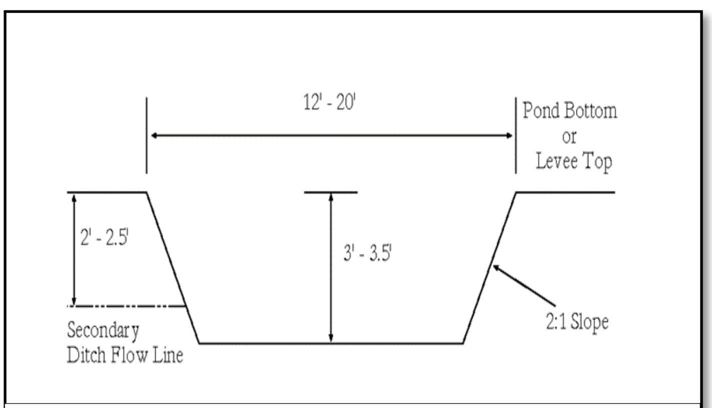


Figure 16. Cross section of primary ditch

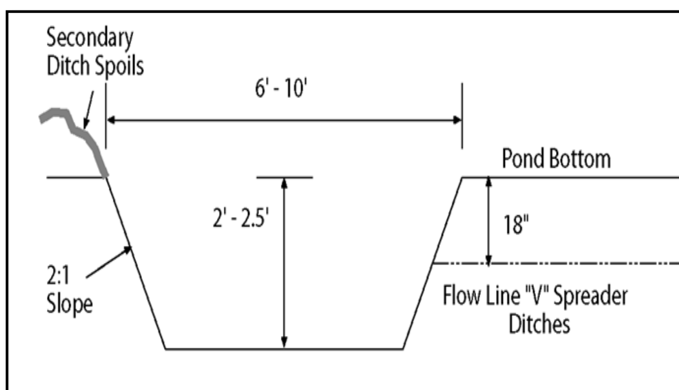


Figure 17. Cross section of secondary ditch

maintenance of "V" ditches such as removing vegetation and buildup of sediment, they have become less common and are being replaced by swales, which are wider and easier to maintain.

Swales are commonly used to increase the drainage of isolated low spots in ponds (pooling water can cause soil salt deposition on the soil surface), enhance leaching of pond soils, and improve circulation. Swales are typically 2 feet deep with gradual slopes. Spreader ditches (lateral ditches) are also used as water conveyance facilities to connect low spots within the ponds to the main ditches. The standard design for spreader ditches is a minimum width of 18 inches, and a minimum depth of 12 inches below the ground level at lowest portion of the service area.

C.2.1.2 Water Management

Most wetland managers in the Marsh begin flooding their wetlands around October 1st in preparation for the fall migration of waterfowl. When possible, wetland managers in the Marsh use gravity flow to fill and drain their wetlands. Consequently, the wetlands are filled during high tide when the water can flow through the water control structures into the managed wetlands. By definition, a pond is any area that is under water when a managed wetland is flooded to normal shooting level (the depth of water maintained in a managed wetland during the hunting season). Ideally, a water depth of 8-12 inches is preferred by most of the waterfowl using the Marsh (SRCD 1980).

The managed wetlands are drained or circulated at low tide when the water elevation in the diked wetlands is higher than that of the slough, and water can flow out through drain gates and into the slough by gravity. During initial flood-up, the inlet gates are opened, and the drain gates remain closed to allow the managed wetlands to fill to an average depth of 8-12 inches. After initial flood-up, water is diverted from adjacent sloughs, circulated, and then drained while maintaining a water depth of 8-12 inches. Compared to the initial flood-up period, relatively small amounts of water are exchanged between the sloughs and the ponds during circulation. Water circulation is critical to maintain water quality and prevent development of stagnant areas. Water circulation also helps decrease pond water salinity by preventing evaporative loss and maintaining natural salinities.

Water manipulation for habitat development usually begins in February through July, depending on whether the landowner is following the recommendations of early or late drawdown manipulation schedules or some modification of these schedules. Typically, the water remaining in the managed wetlands is drained in June or July to allow vegetative growth and to perform routine maintenance activities during the summer work season.

C.2.1.3 Tidal Cycles

Tides are a major diurnal factor influencing successful managed wetland operations. By definition, tides are the rise and fall of sea levels produced by the gravitational forces from the moon and sun. Even though the moon is smaller than the sun, its proximity to the Earth gives it a tidal influence greater than twice that of the sun. A tractive force is responsible for creating a tidal bulge on the side of the Earth facing away from the moon twice a day. This results in two high and two low tides per day for most Pacific coast locations (NOAA 2018). Tidal marshes are distinguished from other wetland systems due to their inundation regimes that are driven by tidal cycles and seasonal precipitation levels. Tides bring water into a wetland once or twice per day depending on diurnal (one high tide and one low tide per day) or semi diurnal (two high and two low tides at the same height per day) tides. River flows can also add depth and duration to the tidal inundation regime. The San Francisco Estuary experiences a mixed, semi-diurnal tidal regime with a 24.8-hour cycle in which two daily tides of unequal height occur (**Figure 18**).

Work activities in the Marsh are highly dependent on tide since much of the water infrastructure is influenced by the tide (sloughs or bays). The optimal time to fix or replace a water control structure or gate is during low tides, since the pipe is more likely to be exposed and uncovered by water and the activity can be completed consistent with permitting Best Management Practices (BMPs) and required construction methods. Similarly, managed wetlands drain best during low tides due to a decrease in pressure on the exterior water control gates. When the pressure is decreased the water control gates can open more easily, allowing the club to drain more effectively. The SRCD website has a direct link to tidal stages in the Marsh (**Figure 19**). https://suisunrcd.org/hydrology/#currenttidelevels.

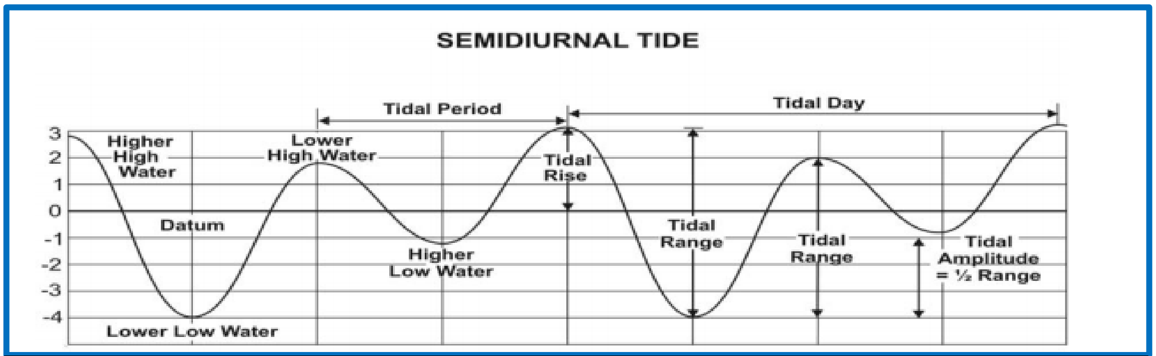


Figure 18. Diagram of mixed and semi-diurnal tides of the San Francisco Estuary (NOAA 2018).

During full or new moons, a spring tide (also known as king tide) occurs which produces higher and lower tides than average (https://oceanservice.noaa.gov/facts/springtide.html). The name spring has nothing to do with season, but rather the term is used from the concept of the tide "springing forth". Spring tides occur twice each lunar month all year long, independent of the season. Seven days after a spring tide, the moon is in quarter phase, which causes the moon and sun's gravitational forces to counteract each other resulting in neap tides. A neap tide is a tide that is at its lowest range. Neap tides occur during the first and third quarter moon, when the moon appears "half full".

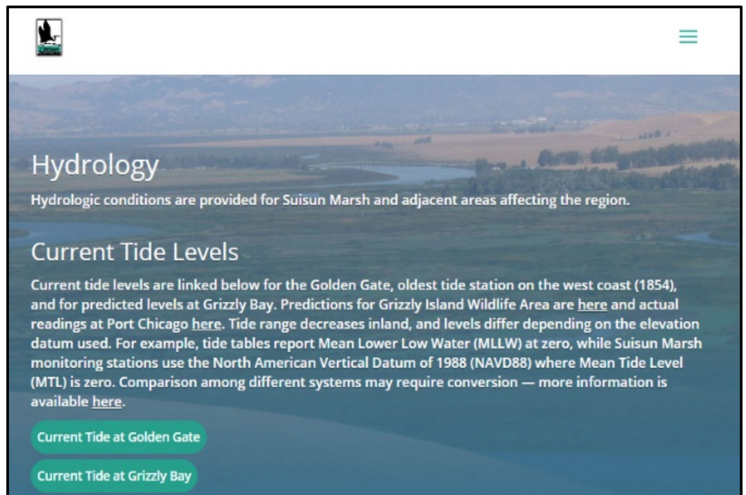


Figure 19. SRCD website information on tidal stages in the

The spring tide for the North Bay, Suisun Bay, and the Delta is a progressive wave combined with Delta outflow that dampens tides from the Port Chicago tidal monitoring station and the tidal monitoring station at Rio Vista. This tidal exchange is a fundamental determinant of water surface levels, direction, volume of flow, and salinity, which applies an essential influence on the biological, physical, and chemical conditions of the Estuary (Siegel et al. 2010).

C.2.1.4 Suisun Marsh Hydrology and Water Quality Standards

Salinity is a major water quality variable for management in the Marsh since it affects the ability of the managed wetlands to produce vegetation and habitat conditions necessary to support waterfowl. Marsh salinity mainly is controlled by salinity in Suisun Bay (SMP) and Delta outflows. The applied salinity, drainage practices, and leaching cycles affects soil salinities in managed wetlands which may limit the vegetation that is considered ideal for waterfowl (DWR 2000).

In August 1978, the State Water Resources Control Board (SWB) issued Water Right Decision 1485 (D-1485), which set channel water salinity standards for the Marsh from October through May to preserve the area as a brackish water tidal marsh and to provide optimal waterfowl plant food production (SWB 1978). D-1485 placed operational conditions on water right permits for the Central Valley Project (CVP) and State Water Project (SWP). Order 7(a) of D-1485 required the permittees to develop and fully implement a management plan, in collaboration with other agencies, to ensure that the salinity standards are met in the Marsh (DWR 1999; **Figure 20**).

In 1987, DWR, USBR, DFW, and SRCD signed the Suisun Marsh Preservation Agreement (SMPA 1987) as a contractual framework for implementing the Plan of Protection including plans for physical facilities to control channel water salinity. The Suisun Marsh Salinity Control Gate (SMSCG) was constructed on Montezuma Slough and began operation in 1988. The SMSCG proved to be effective on the east side of the Marsh to control salinity levels, however it could not meet the objectives at two of the western compliance stations. The newly revised SMPA (SMPA 2015) has determined that waterfowl habitat can adequately be protected under the current salinity regime through more efficient use of channel water and improved land management. Leaching cycles and pond recirculation are critical components of active water management, in addition to variation in salinity between high and low tides.

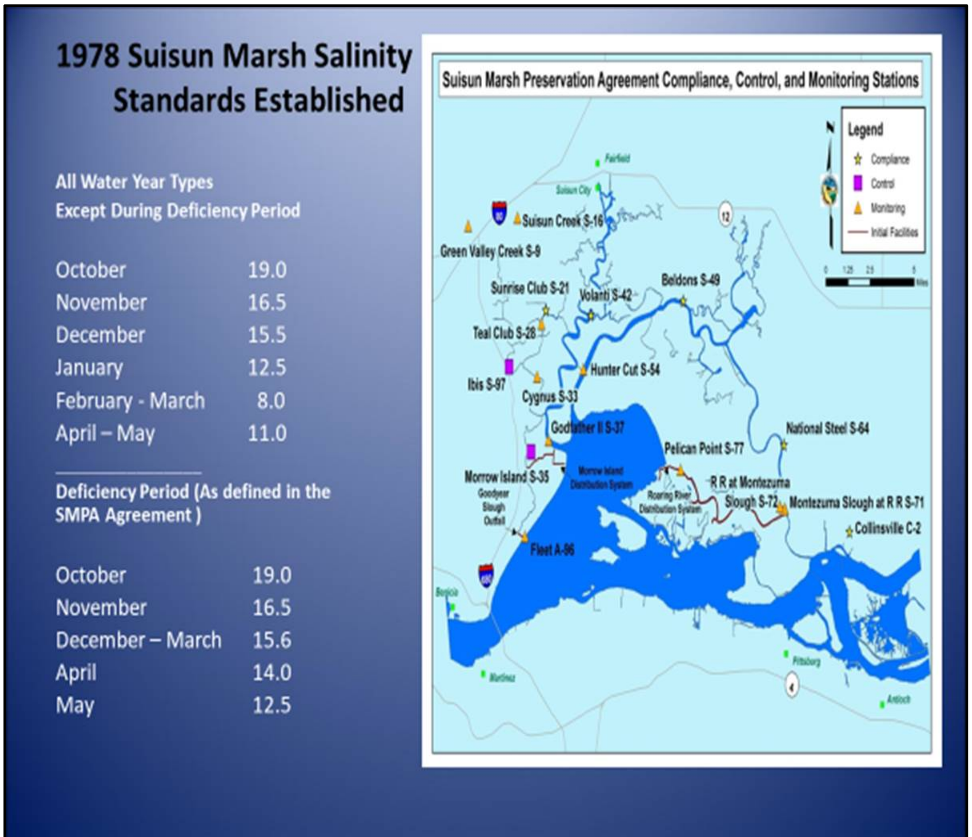


Figure 20. Suisun Marsh Salinity Standards from SMPA and DWR monitoring stations in Suisun Marsh.

In addition to the tidal stages and its influence on the Suisun Marsh, the Delta outflow is considered one of the most significant driving forces on Suisun Bay and its environment (Kimmerer 2004). Delta outflow includes total inflow from the Sacramento River (the primary source), San Joaquin River, northwest tributaries (Yolo Bypass), east side tributaries, and southwest (Siegel et al. 2010). Since 1998, the Water Quality Control Plan has been updated many times, but the Marsh salinity standards that protect the beneficial uses are still in effect in Water Rights Decision 1641 and the SMPP.

The Marsh wetlands are listed on the Clean Water Act 303(d) as being impaired by mercury, nutrients, and organic material/low dissolved oxygen (DO), and salinity since 1992. Slow-flowing, low-mixing, back-end sloughs in the western portion of the Marsh are specifically prone to low DO due to a mixture of natural and anthropogenic factors. The recently approved total maximum daily load (TMDL) was established by the SFBRWQCB through a 401 Water Quality certification (**Table 3**). The monthly standard was set to 5.0 mg/L, and the daily standard was set to 3.8 mg/L.
Water quality in the Marsh is influenced by the flows form the Sacramento-San Joaquin Delta, tides, runoff from local watersheds, and effluent from the Fairfield-Suisun Wastewater Treatment Plant, which participates in advanced secondary treatment (SFRWQCB 2018). Low DO events occur when oxygen concentrations are depleted in bodies of water. Low DO may lead to stress or mortality of sensitive aquatic organisms including

fish. In addition, methylmercury (MeHg) production levels may become elevated with drying and wetting conditions that is bioavailable and magnifies up food chains causing deleterious effects to higher trophic level consumers (Siegel et al. 2011).

DO Objectives	DO concentrations	Applicability
Acute objective	3.8 mg/l minimum (daily average)	Year-round in all sloughs and channels
Chronic objectives	5.0 mg/l minimum (30-day running average)	Year-round in all sloughs and channels
	6.4 mg/l minimum (30-day running average)	January 1 through April 30 in Montezuma, Nurse, and Denverton sloughs only

Table 3. DO concentrations in Suisun Marsh (SFRWQCB 2018).

The managed wetlands are flooded during the fall starting around October 1st in preparation for the fall return of the migratory waterbirds. Vegetation in the wetlands starts to decompose which may result in the depletion of oxygen and the production of sulfites. The pond water is circulated, and any material suspended in the pond water can potentially be discharged into the slough. Significant depressions in DO concentrations have observed at certain times a year in the Peytonia, Boynton, Suisun, and Goodyear Sloughs. Other factors that may contribute to low DO includes storm water runoff, warm water temperatures, boat waste, and agricultural activities in the upper watershed.

Recent studies have tested some of the Best Management Practices (BMPs) on vegetation and discharge management for managed wetlands that may reduce the potential for low DO events (See **Section E.2.2** Water Quality Monitoring). Landowners who implement these BMPs may contribute to better water quality and reduction in the chance of a low DO event.

- **Hydrology Management (H-1 to H-14):** modifying the management of club or slough hydrology to (1) reduce or prevent conditions in the wetlands that may produce low DO events, (2) restrict the amount of low DO water discharged from the clubs at any one time, (3) discharge water to sloughs more capable of assimilating and dispersing low DP water, and (4) change the hydrology of the receiving sloughs to improve their capacity to assimilate and disperse low DO water (**Appendix N**).

- **Carbon (Vegetation and Soil) Management (VS-1 to VS-5):** reducing the amount of labile organic carbon present on the managed wetlands, the “fuel” for the production of low DO conditions. BMPs rely on (1) managing vegetation type, (2) eliminating or changing the schedule of mowing activities, (3) removing mowed vegetation, and (4) reducing soil disturbances such as discing (**Appendix N**).

BMPs for the managed wetlands in the Marsh were created as a guide to assist landowners on improving water quality (**Table 4)**. Fall flood-up, which includes large water diversions from sloughs to flood lands, can lead to reduced DO levels and increase concentrations of constituents (methyl mercury) entering waters (Siegel 2010). SRCD Water Managers work with DWR on water quality monitoring in local sloughs and channels to monitor DO levels and advise landowners on their flooding and draining practices.

BMP Item #	BMP Description
Water Management-Based BMPs: Initial Fall Flood-Up Period	
1	Pre-flood to shoot level, drain, immediate reflood
2	Pre-flood to field saturation level, drain, delayed reflood
3	Pre-flood to field saturation level, drain, immediate reflood
4	Flood and hold with minimal exchange
5	Delay flood-up as late as possible before hunt season
6	Reroute wetland drain events to large sloughs
7	Stagger flood/drain events across multiple wetlands
8	Coordinate drain events across multiple wetlands using DO-based discharge scheduling
9	Maximize use of FSSD water for initial flood-up
10	Maximize use of FSSD water discharge into Boynton and/or Peytonia sloughs during drain events
Water Management-Based BMPs: Circulation period (winter, hunting season)	
11	Minimum exchange between wetlands and sloughs
12	Maximize exchange rates and wetland circulation
Water Management-Based BMPs: Salinity, vegetation, and maintenance management period (spring and summer)	
13	Summer irrigation, no drainage
14	Upgrade water control structures to corrosive resistant materials (increase control/circulation)
15	Improve water circulation ditches and swales (ditch cleaning/creation, pond bottom grading)
16	Deepen water circulation system ditches and swales (decrease Fall water level and reduces overall water volume during flood up)
Vegetation and Soil Management-Based BMPs	
17	Manage for less leafy green vegetation
18	Mow vegetation earlier in the season
19	No soil disturbance (no discing)
20	Reduce soil disturbance (discing) activities

Table 4. Examples of Best Management Practices (BMPs) for managed wetlands.

C.2.1.5 Climate Change and Potential Management Effects

The Marsh region will be increasingly affected by climate change induced sea-level rise within the next 30-100 years. Diked managed wetlands are protected by nearly 200 miles of exterior levees and are currently in the intertidal zones. Rising water levels will affect and submerge current shorelines and tidal wetland habitats. The increased pressure of rising water levels and flooding from storm events will threaten levee system integrity and the long-term viability of the existing managed wetlands. Levee foundations will face increased pressure and require raising the levee crown height and width. In some areas, sea-level rise will mean that current managed wetlands will likely be lost. Increased saltwater intrusion from the San Francisco Bay, reduced freshwater flow from the Central Valley, and prolonged droughts could significantly increase regional salinity levels in the Marsh. These increases in salinity could significantly affect wetland diversity, species composition, and existing habitat functions and values of Suisun Marsh managed and tidal wetlands. Further, flood dynamics will likely change over the next decade, with more frequent and extreme storm and rainfall events and associated flood events coming from the Central Valley and local watersheds. Scenario planning will be needed to help project likely impacts on ecosystems and species and to integrate these into long-term conservation planning. Landowners should plan for climate change effects by considering proactive changes such as increasing exterior levee crown heights and installing pumps to increase future drainage capabilities.

C.2.1.6 Significance of Hydroperiod

Inundation regime is the frequency, duration, and depth of flooding by surface waters. The inundation regime is the most significant driver of marsh ecology (Mitsch and Gosselink 2000), since it influences vegetation composition, substrate character, and hydrologic connectivity (Siegel et al. 2010). Marsh management and the water control facilities that manipulate the timing, duration, and depth of flooding play a significant role in determining the Marsh's wetland plant communities (DWR 2001). Wetland managers use various structures such as levees, ditches, water control structures, controllable topography, pumps, and screens to meet management objectives. Financial constraints are often deciding factors on the selection and purchase of water control structures (Barthman-Thompson et al. 2007).

In diked lands of the Marsh, suitable vegetation is a key component to the survival of species such as waterfowl, pheasants, small mammals including the endangered salt marsh harvest mouse (*Reithrodontomys raviventris haliocoetes*), and tule elk (*Cervus elaphus nannodes*). Most habitat management in the managed wetlands is focused on benefiting waterfowl. Factors that affect plant growth in managed wetlands of Suisun include: east-west and north-south salinity gradients; length of soil submergence; soil salinity; water depth; salinity of applied water; manipulation such as discing, burning and mowing; and competition from other plants, including nonnative invasives (DWR 2001 and SRCD 1998).

C.2.1.7 Suisun Marsh Soils

Typically, Suisun soils have black, very strongly acid muck upper layers and black mildly alkaline peaty muck lower layers that become strongly acidic if drained and allowed to oxidize, and the soils are saline (National Cooperative Soil Survey 2001). The Marsh contains five soil series: Joice, Reyes, Suisun, Tamba, and Valdez (DWR 2001). Joice, Reyes, Suisun, and Tamba soils are mixtures of hydrophytic plant remains and mineral sediments whereas Valdez series soils are formed in mixed alluvium (USDA 1975). The soil types generally occur in the following order extending outward from the sloughs: Reyes, Tamba, Joice, and Suisun. DWR evaluated the relationship between soil type and soil water salinity (DWR 2001). No consistent patterns of soil water salinity were seen based on soil type and DWR concluded that other factors such as site location, site elevation, and water management had more significant impacts on soil water salinity than soil type (**Appendix L**).

C.2.1.8 Plant Effects and Salinity Tolerance

To create the appropriate conditions for certain desired plant species, pond water salinity must be maintained at low levels. Low salinities are achieved by exchanging high salinity pond water with the lower salinity channel water in the spring. Water exchanges are most effective when there are high river flows and channel water salinities are low. Salinity standards for the Marsh (**Figure 20**) were established by the SWRCB to protect exiting beneficial uses of water. To comply with these requirements, DWR has established salinity monitoring stations throughout the Marsh that give daily electrical conductivity levels (microsiemens: μS/cm). This real-time salinity data is posted by DWR and can be found on the SRCD website (https://suisunrcd.org/hydrology/). Water exchange (circulation) is conducted as necessary to keep pond water salinity below salinity tolerance levels for desired plant species (Barthman-Thompson et al. 2007). Soil salinity in the top one foot of soil affects the roots zones of most managed marsh plants (Burns 2003). In Suisun Marsh, many waterfowl food plants grow better in the more saline environments of some diked wetlands rather than tidal areas and will thrive unless subject to poor water management regimes or subsidence (Barthman-Thompson et al. 2007). **Appendix R** identifies the habitat values, salinity tolerance, and vegetation requirements for key plants in the Suisun Marsh. The principal controllable factors affecting the type of plant communities in the primary management area of the Marsh are length of submergence and root zone soil salinities. Both factors are determined by water supply quality and management (SRCD 1980).

D. Regulatory Requirements of Managed Wetland Operations

D.1 USACE Regional General Permit 3

The San Francisco District of USACE oversees the Regional General Permit 3 (RGP 3) for the Suisun Marsh Managed Wetlands Operations and Maintenance activities **(Appendix B)** administered by SRCD and DFW to place and maintain structures and/or perform work, and discharge dredged or fill material in areas subject to Corps jurisdiction while completing permitted activities within the Marsh (**Figure 21**). The USACE also provides permits for activities that are not covered under the RGP 3 as Individual or Nationwide Permits.

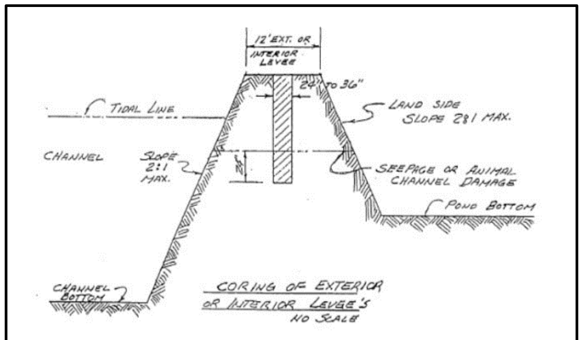


Figure 21. Coring of exterior or interior levee.

RGP 3 has many restrictions and special conditions that protect and minimize impact to species and their habitats in the Marsh. Private landowners working under this permit are responsible for ensuring that all work they or their contractors undertake is in accordance with the terms and conditions of this permit. The SRCD is responsible for providing the required reports and guidance to the landowners. However, the Corps has the authority on determining if an activity is authorized by the RGP 3. Each landowner is required to submit an annual work plan to SRCD for review and USACE approval before starting work each year. The annual amount of work activities permitted on each property is based on acreage or volume of requested activities. All permitted work activities must be within the managed wetlands. Minimal work is permitted on the tidal side of the manage wetlands exterior levee unless it is associated with levee repairs (riprap, bulkhead walls, or alternative bank protection) or water control pipe and gate replacement and installations.

RGP 3 administration can take weeks to obtain authorization. Landowners should plan projects early in the work season, fill out a work request form, and submit them with accompanying maps to SRCD. The SRCD will compile the requests and submit monthly to the USACE for authorization. The USACE has 30 days to review the proposed work activities for authorization. When work activities are authorized by the USACE, SRCD will send the landowners a copy of the RGP 3 authorization letter.

The current RGP 3 authorizes landowners to conduct approved work activities and place fill in wetlands subject to USACE jurisdiction (USACE 2018).

A list of the regulatory agencies that review authorized activities under the RGP3 are:
• NOAA Fisheries aka National Marine Fisheries Service (NMFS)
• U.S. Fish and Wildlife Service (USFWS)
• California Department of Fish & Wildlife (DFW)
• San Francisco Bay Conservation Development Commission (BCDC) Permit
• Regional Water Quality Control Board (RWQCB)
• Environmental Protection Agency (EPA)
• State Lands Commission (SLC)

A summary of activities included in the RGP 3 permit, see (**Appendix B**) for details:

- *Ditches* – work in interior ditches; maintenance of existing spreader ditches and creation of new spreader ditches; replacement of riprap on interior ditch banks; and placement of new riprap on interior ditch banks
- *Levees* - repair of interior and exterior levees; replacement of previously existing riprap on levees, placement of new riprap, and installation of alternative bank protection; coring of levees; installing, repairing, or reinstalling bulkheads; and maintenance of existing roads
- *Activities on Managed Wetlands* – grading, creating drainage swales and loafing islands, and raising the elevation of managed wetlands; discing; installation of permanent pumps and pump platforms; installation, replacement, relocation, or removal of duck hunting blinds; and constructing cofferdams in managed wetlands
- *Activities Associated with Water Control Structures* – replacement and maintenance of water control structures; installation of new interior or exterior water control structures; fish screens; and removal of debris

D.2 Bay Conservation and Development Commission (BCDC) Permitting

This certified Plan meets the regulatory purpose of a BCDC MDP for routine maintenance of existing managed wetlands water management facilities and infrastructure. New managed wetland infrastructure such as exterior drainpipes, rip rap, bulkhead walls, or pump platforms, or an activity, such as dredging or that meet the BCDC definition of "development" (BCDC 1976) will require a BCDC Marsh Development Permit. If new, replacement of existing, or improvements are needed on the clubhouse area, building structures, or boat docks the landowner must consult with Solano County Department of Resource Management (DRM) and BCDC for permitting requirements. The cost of these permits varies according to the type and size of the project.

D.3 USACE Exterior Dredging Permit Letter of Permission (LOP)

SRCD holds a USACE Letter of Permission (LOP) for the Suisun Marsh Dredging Program. This LOP permit authorizes dredging of material from tidal areas of the Suisun Marsh to be used for exterior levee and fish screen repairs and maintenance. The LOP allows for annual dredging of up to total of 100,000 cubic yards of material from tidal sloughs, bays, and dredger cuts in the Suisun Marsh, but with strict regional limitations and construction restrictions.

Summary of LOP permit conditions:

- Work season is August 1st – November 30th of each year.
- All dredging material must be placed on the crown or backslope of the exterior levee only.
- LOP requires a detailed application, strict compliance with work restrictions, Biological Opinions Conditions, and extensive post-construction reporting.

- Work season restrictions apply for the endangered Ridgeway Rail in designated areas (work cannot begin until after August 31st).
- Dredging will not be allowed in channels separated from the levees by vegetated berms greater than 50-feet wide.
- All dredging must avoid emergent and submerged aquatic vegetation in the tidal area where the material is to be obtained.
- Annual permitted dredging volumes are limited by Suisun Marsh region and source habitat type.

See the SRCD website for dredge program information at: https://suisunrcd.org/permits/

D.4 Special RGP3 Permitting Procedures:

The RGP3 has a special permitting procedure quick authorization of urgent and unforeseen maintenance activities, which can be used for exterior levee repairs such as burrowing animal damage, flood fighting and levee breach repair or failed water control structures. For a fillable USACE urgent or unforeseen maintenance activity application see https://suisunrcd.org/permits/.

D.5 Environmental Permits

With the establishment of the SMP in 2014, federal, state, and other government agencies are responsible to comply with federal National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) requirements. NEPA is the nation's broadest environmental law that requires federal agencies to disclose and consider the environmental implications of their proposed actions. Reclamation districts and USFWS will use the EIS/EIR to comply with CEQA and NEPA regulations and compliance (SMP 2011). Prior to conducting a project in the Suisun Marsh, agencies must request information from USFWS and NOAA on the existence in a project area of special-status species or species proposed for listing. Agencies will then prepare a BO to determine whether any special status species or species proposed for listing will be affected by proposed action. If a finding of jeopardy or adverse modifications is made in the BO, USFWS and/or NOAA must recommend reasonable and prudent alternatives that would avoid threat, and the federal agency must modify project approval to ensure that special-status species are not endangered and that their critical habitat is not adversely modified, unless an exemption from this requirement is granted (SMP 2011).

In addition, with the NEPA and CEQA compliance for the SMP, three BOs were issued by the USACE that covers projects that fall under the USACE RGP 3, LOP, and individual permits (see https://suisunrcd.org/permits/).

The Endangered Species Act (ESA) provides for the conservation of species that are endangered or threatened, in addition to the conservation of the ecosystems on which they depend. Permits are required under the ESA to conduct activities that may result in the "take" of a protected species. Section 10 of the ESA allows NOAA Fisheries within the Department of Commerce to issue permits for direct take and incidental take for scientific purposes or to enhance the propagation or survival of listed species. Incidental take permits must be accompanied by a conservation plan, referred to as a habitat conservation plan. As part of the review of the 30-year SMP, a NOAA BO was created to examine the effects of the proposed SMP on listed species (**Appendix F**).

E. Management Options

E.1 Salinity Control

Suisun Marsh exhibits increasing salinity gradients in soil and channel water from east to west and from north to south. Factors affecting the salinity in the sloughs of the Marsh include, but are not limited to tides, climate, delta outflow, SMSCG operations, creek inflows, managed wetland operations (as allowed under current regulatory restrictions), urban runoff, and Fairfield-Suisun Treatment Plant effluent flows (**Figure 23**). The first five factors have the greatest impacts on slough water salinity, while the last three factors have temporary or localized effects. Pond water salinity tends to be directly related to slough water salinity, but many times there is a lag in pond water salinity response to changes in channel water salinity from months to a year.

Figure 23. Suisun Marsh Salinity Control Gate.

During times of high Delta outflow, the Marsh has a natural salinity gradient from east to west. The eastern Marsh, being closest to the Delta, will have lower channel salinities than the western Marsh. When Delta outflow is low, the operation of the SMSCG lowers the salinity in eastern marsh channels and maintains the east to west gradient. Without Control Gate operations during times of low Delta outflow, the salinity in the western Marsh may be lower than that at some eastern Marsh locations.

When Delta outflow increases, salinity in the eastern Marsh drops rapidly. However, the southwestern Marsh requires high outflow for a longer period of time to achieve a reduction in salinity. Field data and simulation modeling indicate that northwestern Marsh salinity is primarily affected by SMSCG operations and inflows from the watershed to the north and northwest, and by local drainage from managed wetlands. The Marsh also has a north-south salinity gradient, with the northern Marsh having lower channel salinity during wet months due to local runoff and creek flows.

E.1.1 Leaching Cycles

Rollins (1973) investigated the effects of applied water salinity on soil water salinity. He concluded that there was a significant relationship between applied water salinity and the soil water salinity and that leaching with low salinity water reduced soil water salinity.

The influence of applied water salinity on pond water salinity depends on the water management cycle. Water management actions may mask effects of applied water salinity on pond water salinity. During flood up (September and October, see Barthman-Thompson et. al 2007), pond water salinity is often independent of applied water salinity because salts that accumulate on or near the surface of the soil during the summer are absorbed by pond water, causing pond water salinity to be substantially higher than the applied water salinity (DWR 2001). From December through February, pond water salinity is close to the applied water salinity because circulation of pond water with slough water continually removes the more saline pond water while replacing it with less saline slough water (DWR 2001). The USDA (1977) stated that appropriate circulation of pond water and leaching of soil salts prevents increases in soil water salinity above natural levels for the Marsh soils. During leaching cycles from February to May, pond water salinity generally corresponds to applied water salinity except during the final drain due to a lack of water being applied to the pond coupled with the remaining water absorbing more salts from the soil.

E.1.2 Soil Salinity Control

Suisun Marsh soils that were historically inundated by the brackish tides are saline soils (DWR 2001). These soils were always moist as tidal wetlands and the presence of water in the soil combined with the flushing action of tides keeps the salt concentrations at fairly constant levels (DWR 2001).

Managed wetlands dry conditions in the summer cause the salinity of the soil water to increase as water is lost through evaporation and saline water is drawn up from lower areas of the soil profile (DWR 2001). Soil deeper than one foot has a high salt content and acts like a salt bank because capillary action and hydrostatic pressure brings highly saline water to the surface of the soil to replace evaporative water loss (USDA 1975). As a result, to maintain a favorable low salt concentration in the soil seasonally flooded ponds must be leached out annually. A 30-day leach cycle can measurably decrease soil water salinity immediately afterwards although about half of the leached sites had soil water salinities equal to or greater than the salinity before the leach cycle (DWR 2001). It is almost impossible to reduce the salt concentration in soils below levels where water is available for leaching and flushing the ponds (USDA 1975). High concentrations of soil water salinity can lead to salt-scalded bare ground that is toxic to plants (DWR 2001).

DWR (2001) data also suggests that soil water salinity is affected by location relative to water control structures such as intakes and circulation ditches. Sites near these structures tended to have lower soil water salinity than more distant sites. If a pond has intakes from different sources, the salinity may vary across the pond relative to the proximity to the different water intakes or if the pond has a freshwater influence from local runoff (DWR 2001).

Proper water control allows managers to perform important leach cycles that help prevent soil salt accumulation. Soil salinity dictates the type of vegetation that may occur within a managed wetland (Burns 2003). [Water] salinity is the primary factor encouraging the growth and seed production of marsh plants (Rollins 1973 and 1981, Michny 1979, Casazza 1995). The ability to move water on and off a property efficiently should help decrease soil salinity and thereby potentially cause an increase in desirable wetland plant diversity.

E.2 Wetland Management Constraints

Managed wetlands contain many challenges and constraints such as aging facilities, threatened and endangered species, regulations, subsidence, mosquito abatement, and salinity issues. However, they provide a valuable resource for both wildlife and people.

E.2.1 Mosquito Control

The SCMAD sets forth management schedules and practices for duck clubs, tidal marshes, leveed irrigated pastures, and permanent ponds. As California becomes more urbanized and development encroaches into historically rural areas, conflicts can arise from public health concerns about mosquito production in wetlands. Mosquito abundance reaches its peak during the flood-up of seasonal wetlands during late summer and early fall (**Figure 24**). In the Marsh, hundreds of acres of seasonal wetlands can be flood per week causing a constant influx of new mosquito colonies during the flood-up period. There is also a second smaller and shorter peak mosquito production during the spring and summer irrigation of seasonal wetlands. However, this involves less acreage and is temporary since the irrigations are usually completed in 7 – 10 days (Kwasny et al. 2004).

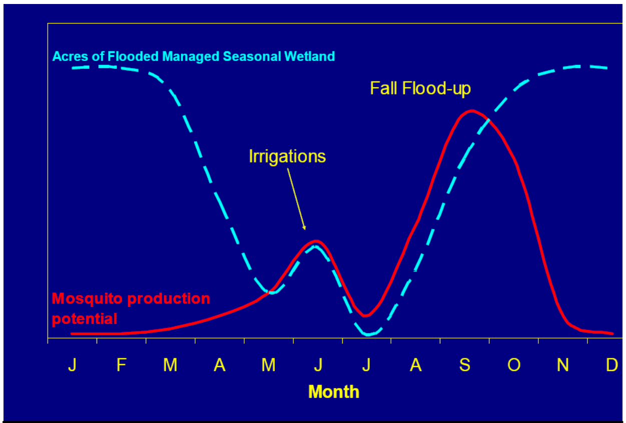


Figure 24. Mosquito lifecycle in Suisun Marsh.

Mosquitoes are dipteran insects with aquatic immature stages and an aerial adult stage. They have four aquatic larval stages (instars) plus an aquatic pupal stage. The adult emerges from the pupal stage onto the surface of the water, expands its wings, hardens its exoskeleton, and flies off. Depending on seasonal and environmental conditions and the particular mosquito species involved, it generally takes from three to 12 days for a mosquito to complete its life from developed egg to early adult stage. In general, as ambient temperature increases, the number of days required from hatching to emergence decreases. There are five primary species of mosquitoes that can be produced in managed wetlands and that fall within two categories based on life history traits: floodwater mosquitoes (*Aedes melanimon* and *Aedes dorsalis*) and standing water mosquitoes (*Culex tarsalis, Culex erythrothorax,* and *Anopheles freeborni).*

Floodwater mosquito lifecycle begins with flooding of ground that has undergone a dry period. Once flooded, the eggs from the previous dry cycle hatch, pupate, and emerge as adults. The adult females are relatively aggressive and feed primarily on mammals. Floodwater mosquitoes are also the most abundant mosquitoes produced by managed seasonal wetlands, particularly during summer irrigations and fall flooding. They have been identified as a primary nuisance species and as a secondary vector for California encephalitis virus and western equine encephalitis, and moderate vector of West Nile virus.

Standing water mosquitoes lay their eggs on the water surface in bunches called rafts. Each raft contains 100 - 150 eggs, hatching anywhere from 24 hours after being laid or up to 7 to 9 days, depending on the species of mosquitoes (Kwasny et al. 2004). The eggs can be found in almost any source of water except tree holes. Peak populations occur in late June or early July. Adults can emerge continuously throughout the summer and fall in areas that have been flooded for an extended period of time (greater than 2-3 weeks). More detailed information on mosquitoes can be found in the Central Valley Joint Venture: Technical Guide to Best Management Practices for Mosquito Control in Managed Wetlands **(Appendix Q)**.

Costs to landowners for mosquito control (aerial spraying after fall flood) can be substantial. Some of the regulatory restrictions have reduced the landowner's ability to control mosquito production on their properties. For example, burning and extensive discing salt grass is effective for mosquito control, but these activities may be restricted by regulation.

SRCD partners with the SCMAD to provide a Fall Flood-Up Program. The goal is to reduce production of mosquitoes through water and habitat management during the flood up of the managed wetlands. SCMAD technicians inspect the property after the initial flooding of the property and, if excessive mosquito larvae are present, the SCMAD will treat any properties that produce large quantities of mosquitoes and abate mosquito production under the Public Health and Safety code (see https://suisunrcd.org/programs/#fallfloodup

E.2.2 Water Quality Monitoring

Low DO events in the Marsh are of concern because they can lead to undue stress and even mortality of sensitive aquatic organisms. Elevated methylmercury (MeHg) levels produce a neurotoxin that bio-magnifies up the food chain and can cause deleterious effects to higher trophic level consumers such as piscivorous fish, birds, and mammals, including humans (Siegel et al. 2011). During the initial fall floods, organic material in managed wetlands starts to decompose which may result in the depletion of oxygen and the production of sulfites. When pond water is circulated, any material suspended in the pond water can potentially be discharged into the slough.

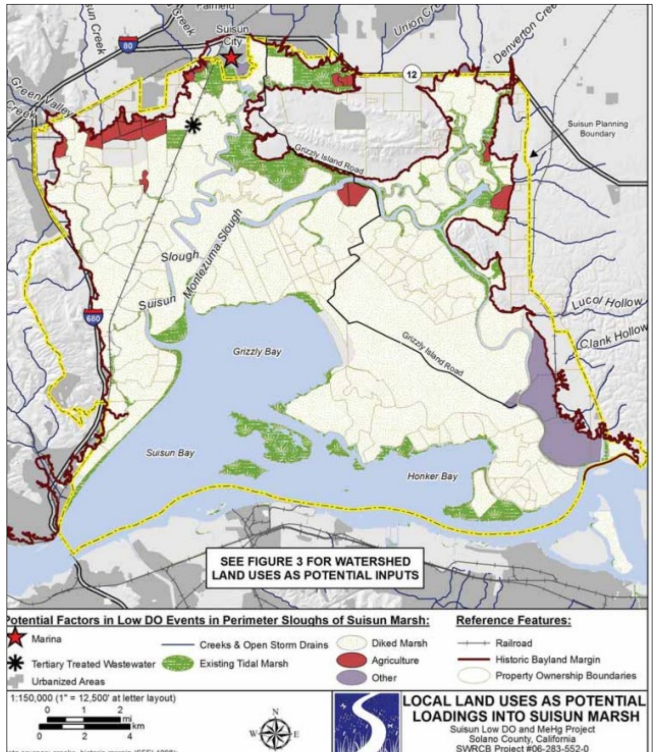


Figure 25. Potential factors in low DO event in perimeter sloughs in Suisun Marsh.

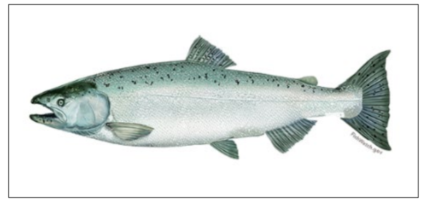
While in most cases water is discharged into large sloughs at low tide, becomes diluted in the slough, and is therefore harmless, there have been some events that have caused concern. The primary concern is low DO events in small, dead-end sloughs adjacent to managed wetlands. Significant depressions in DO concentrations have observed at certain times a year in the Peytonia, Boynton, Suisun, and Goodyear Sloughs of the Marsh (**Figure 25**). These depressions coincide with the fall flood-up and discharge cycles of the diked managed wetlands that border these small, dead-end sloughs. Other factors that can contribute to low DO include storm water runoff, nearby tidal marshlands, warm water temperature, illegal waste from boats in the Suisun Marina, and from agricultural activities in the watershed upstream of Suisun Marsh. Low DO events can be accompanied by elevated concentrations of MeHg (Siegel et al. 2011).

Water diversion restrictions have a major impact on marsh management activities, especially during the first two months after flooding. Some properties are restricted to the point of not being able to maintain proper water levels while other properties cannot maintain an adequate circulation rate to properly flush salts and organic materials from their ponds. The results of both problems are poor water quality and decreased wildlife use.

E.2.3 Listed Species

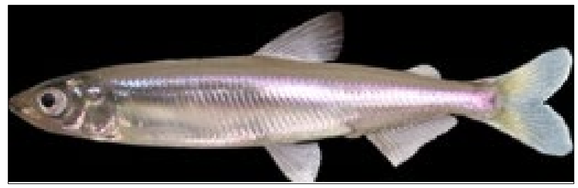
Several state and federal listed or protected species can be found in the Marsh. Wetland managers must follow state and federal restrictions in their day-to-day operations to protect these species and their habitats. Other Species of Concern may also be present, although species with this designation have no official state or federal status. The DFW is the state agency charged with enforcement of the California ESA and the Native Plant Protection Act to protect and preserve threatened and endangered species. The USFWS and NOAA are charged with enforcement of the Federal ESA. Through Section 7 of the ESA, these agencies issue BOs of projects that may include conditions to protect species covered by the ESA. In the Marsh the USFWS and NOAA have mandated restrictions on the timing and location of maintenance activities and diversions through BOs issued on the RGP 3.

E.2.3.1 Chinook Salmon*



Suisun Marsh supports fish from the winter run and spring run Chinook salmon populations. The spring-run Chinook salmon are an ecologically significant unit (ESU) that includes naturally spawned spring-run Chinook salmon originating from the Sacramento River and its tributaries and also from the Feather River Hatchery Spring-run Chinook Program with population estimates of a few thousand individuals. The winter-run Chinook salmon is an endangered species that includes all naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries in California, as well as the Livingston Stone National Fish Hatchery supplementation program with population estimates of less than a thousand individuals.

E.2.3.2 Delta Smelt*

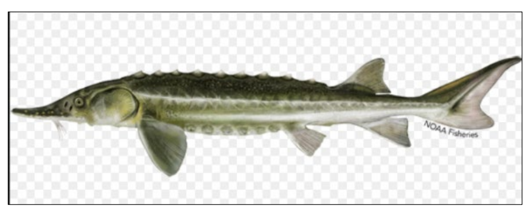


Delta smelt (*Hypomesus transpacificus*) was listed as threatened by both the State of California and the federal government in 1993. Critical habitat was designated for delta smelt in 1995 and includes: Suisun Bay (including the contiguous Grizzly and Honker bays); the length of Goodyear, Suisun, Cutoff, First Mallard, and Montezuma sloughs; and existing continuous waters within the Sacramento-San Joaquin Delta.

This species is a seasonal resident of primarily larger sloughs and inhabits open surface and shoal waters of main river channels and Suisun Bay (SFEP 1992). Their normal downstream limit appears to be western Suisun Bay, although during periods of high outflow, they can be washed into San Pablo and San Francisco bays where they do not establish permanent populations (SFEP 1992). Data from the UC Davis Fisheries Monitoring Program indicate that delta smelt may be found in Marsh throughout the year. Results from the 1995 larval sampling indicate that delta smelt use the Marsh for spawning and rearing. Results from UC Davis fisheries monitoring indicate that delta smelt abundance in the Marsh has been declining since at least the early 1980s (Matern 1996).

Landowners are given the opportunity to intake water until February 21, before intake restrictions take effect for Delta smelt from April 1st to May 31st of each year. Water diversion may begin during the restriction time period of April 1st – May 31st; however, landowners can only use 35% of the water control structure's intake capacity.

E.2.3.3 Green Sturgeon



Green sturgeon (*Acipenser medirostris*) is designated as a Species of Concern by the DFW. In California, green sturgeon has been collected in small numbers in marine waters from the Mexican border to the Oregon border. They have been noted in a number of rivers, but spawning populations are known only in the Sacramento and Klamath Rivers. The San Francisco Bay system, consisting of San Francisco Bay, San Pablo Bay, Suisun Bay and the Delta, is home to the southern-most reproducing population of green sturgeon.

In the Marsh, green sturgeon are primarily transient or migratory. Matern (1997) reported that surveys from 1979 through 1997 in the Marsh resulted in only one green sturgeon being caught (April 1996). Green sturgeon adults tend to occur more frequently in marine environments than either brackish or fresh water. While the Marsh may provide some habitat for green sturgeon, it is used as a migratory path to and from spawning habitat as these fish spawn in deep, cold, clean, fast-moving freshwater environments (Moyle 1995). Green Sturgeon are rarely captured in Suisun Marsh. The Marsh does not provide spawning habitat and is used mostly as a migratory path (Moyle 1995).

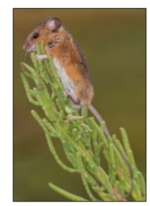
E.2.3.4 Central Valley and Central California Coast Steelhead

The Central Valley steelhead (*Oncorhynchus mykiss*) is federally listed as threatened. Central Valley steelhead occupy the Sacramento and San Joaquin Rivers and their tributaries which offer the only migration route to the drainages of the Sierra Nevada and southern Cascade Mountain ranges for anadromous fish. Central Valley steelhead is a migratory/transient species. They have been captured intermittently in the Marsh by the UC Davis Fisheries Monitoring Program (Matern 1997) and have historically been found in Suisun Creek (Leidy 1984).

E.2.3.5 California Ridgway's Rail (formerly Clapper Rail) *

The California Ridgway's rail (*Rallus obsoletus obsoletus*) is a federal and state listed endangered species and a DFW Fully Protected Species. The USFWS 1994 BO restricts maintenance activities in or adjacent to tidal marsh habitat during the nesting season, from February 1st through August 31st. These work restrictions may be relaxed if surveys are conducted and clapper rail nesting territories are not found within 500 feet of proposed work. California Ridgway's rail are considered non-migratory residents of San Francisco Bay, but post breeding dispersal within the estuary has been documented during the fall and winter (Orr 1939, Wilber and Tomlinson 1976).

E.2.3.6 Salt Marsh Harvest Mouse



The salt marsh harvest mouse (*Reithrodontomys raviventris haliocoetes*) (SMHM) was listed as endangered by the USFWS in 1970 and by the California Fish and Game Commission in 1971. The SMHM is also a DFW Fully Protected Species. A recovery plan for the species was prepared by the USFWS in 1984 that was incorporated into the Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California, and that section is currently under revision. In the recovery plan, the USFWS did not declare any critical habitat within the Marsh, however, several areas were classified as essential to SMHM including Joice Island north, Joice Island south, Suisun Slough north (the area between Goat Island and the mouth of Wells Slough), and Collinsville (USFWS 1981). Twenty-five hundred acres have been set aside in conservation areas for the SMHM in the Marsh.

The SMHM has been found throughout the Marsh in a variety of habitats. Current studies show that pickleweed is not necessarily the most "preferred" habitat as defined by the USFWS recovery plan (DFG & DWR unpublished data) and their distribution is not restricted to pickleweed habitat (Smith et al. 2020). Ongoing genetic studies of the SMHM in the Marsh show that the population is genetically diverse (Stathem and Sacks 2019). This finding indicates that wetland management practices have not caused SMHM populations to become isolated and less genetically diverse.

As studies redefine "preferred habitat", managed wetlands may be found to provide higher quality habitat for the SMHM than previously believed. SMHM may also be impacted by flooding if no refugia are available. Current studies include deriving and comparing population size and density estimates across distinct habitat types (e.g., diked and tidal wetlands) to determine the significance of any differences in various parameters across sampling locations and time. The secondary goal of these studies is to explain the relationship between seasonal demography and microhabitat characteristics in the Marsh. The results of these studies will ultimately allow the formulation of a more inclusive quantitative measure for gauging the quality of a given habitat patch for conservation purposes (Barthman-Thompson et al. 2007).

E.2.3.7 Suisun Thistle, Soft Bird's Beak, Contra Costa Goldfields, Delta Tule Pea, Mason's Lilaeopsis

The tidal marsh plains provide habitat for native plant species such as soft bird's-beak and Suisun thistle (SMP EIR 2014). Soft bird's beak (*Cordylanthus mollis ssp. mollis*) occurs in the high salt and brackish tidal marsh of northern San Pablo Bay and the Marsh area, and in some diked brackish marshes with limited tidal circulation. It has an affinity for the higher, well-drained portions of the Marsh and the edges of salt pans. It occurs primarily in portions of the middle marsh and high marsh zones where the dominant vegetation includes gaps and areas of sparse vegetative canopy cover, often in association with *Sarcocornia pacifica* and *Distichlis spicata* (saltgrass). The invasion of the middle and upper brackish tidal marsh zones by non-native *Lepidium latifolium* is potentially detrimental to soft bird's beak.

Suisun Thistle is endemic to California and is only found in the San Francisco Bay Area and the Sacramento-San Joaquin River Delta. It grows in wet boggy environments. It is listed as endangered by the USFWS. Suisun thistle grows in the upper middle marsh plain and high marsh, usually associated with small tidal creek banks that locally drain the Marsh peat surface. It is influenced by soil salinity and drainage and restricted to freshwater-influenced brackish marshes. Its extreme historical decline was due to diking and reclamation of nearly all the tidal marshes in the Marsh for either agriculture or waterfowl production (Raabe et al. 2010).

Contra Costa goldfields is listed as endangered by the USFWS. Existing populations vary widely in size from ten to 250,000 (CNDDB 2003). Contra Costa goldfields inhabit vernal pools and seasonally moist grassy areas, including disturbed grasslands and swales (CALFED 1999, CNDDB 2003). Contra Costa goldfields can be found in four places in Suisun: on private property on the extreme northwestern edge of the Marsh in a grassy causeway and along the banks of a pond, on private land on the northeastern edge of the Marsh near Ledgewood Creek, just south of State Highway 12 near the terminus of Hill Slough and the Potrero Hills Landfill, and on private land slightly southeast of the Hill Slough/landfill site near Scally Road. The two populations near the landfill have significant populations, both with recent counts above 100,000 (CNDDB 2003, DWR 1999).

Delta tule pea is another threatened and endangered rare plant species that occurs along riverbanks, tidal slough edges, and the outboard side of levees subject to tidal influence (DWR 1999). In the Marsh, this species is often partially inundated during high tide (DWR 1999). Delta tule pea is often found growing with another rare plant, Mason's lilaeopsis (CNDDB 2003). Delta tule pea is threatened by levee construction and maintenance, including addition of riprap, and by removal of levees such as through tidal restoration. It may also be threatened by agriculture, water diversions, dumping of dredged material, recreation, fishing, sheep grazing, trampling, erosion from jet ski and motorboat wakes, and golf course maintenance. Non-native invasive plants may further threaten this plant, however, Delta tule pea has been observed to simply climb up and over other plants, such as perennial pepperweed (CNDDB 2003, DWR 1999).

Mason's lilaeopsis is listed as Rare under the California ESA. Mason's lilaeopsis grows in the low intertidal zone of sloughs, channels, and islands, and on the outboard sides of levees where there is an exposed and actively eroding shoreline (DWR 1999).

E.2.3.8 Mammals, Raptors, Shorebirds, and Other Water Birds

Upland areas managed for mallard nesting habitat also provide feeding, nesting, and cover habitats for many non-waterfowl species. Ground nesting birds (northern harrier, short-eared owl), raptors (white-tailed kite, red-tailed hawk, northern harrier, American kestrel), and passerines (western meadowlark, savannah sparrow, horned lark) benefit from upland habitat enhancement designed to increase waterfowl nesting success.

Managed wetlands and associated upland areas also provide habitat for many mammal species. Most of the common mammals found in the Marsh (Virginia opossum, northern river otter, coyote, raccoon, striped skunk, black-tailed jackrabbit, common muskrat, etc.) maintain healthy populations without the need for special management programs. Species such as the tule elk, which have benefited from intensive management programs in the past, are now thriving under typical marsh management strategies. Many small mammals (ornate shrew, broad-footed mole, coyote, California ground squirrel, botta pocket gopher, western harvest mouse, California vole) benefit from upland habitat enhancement designed to increase waterfowl nesting success (Barthman-Thompson et al. 2007).

E.2.3.9 Fish – Longfin Smelt, Sacramento Splittail

Sacramento Splittail (*Pogonichthys macrolepidotus*) is listed as a federal and DFW Species of Concern and is a large minnow endemic to the Bay-Delta estuary. Splittail are a year-round inhabitant of the Marsh and move in and out of large and small dead-end sloughs (Barthman-Thompson et al. 2007). Longfin smelt (*Spirinchus thaleichthys*) is designated as threatened species by the DFW. In California, the largest longfin smelt reproductive population inhabits the San Francisco Bay-Delta estuary. Regulatory restrictions for management and diversion closures are imposed for all unscreened diversions during longfin and splittail species presence in Suisun. Intake restrictions are also in place to reduce or eliminate fish entrainment.

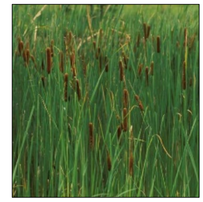
E.2.4 Invasive Species and Weed Control

Both native and non-native plants can be considered invasive, depending upon the desired habitat. Non-native plants generally provide little or no benefits to wildlife. Natives may be considered invasive if they compete with plants more suited to the target animal or group of animals (e.g., Baltic rush in duck ponds). Plants may also need to be controlled if they become too dense or impede water flow. Mechanical and chemical methods as well as water manipulation are all available for invasive control. In spring to early summer, plants are mowed, sprayed, disced, and then sprayed again. Discing is recommended only after spraying.

One of the most problematic non-natives in the Marsh is perennial pepperweed (*Lepidium latifolium).* Pepperweed invades both upland and wetland areas, including tidal zones where spraying is generally not permitted. It forms dense monospecific stands in a wide variety of habitats and is very tolerant of a wide variety of salinities. Stems and roots increase in density over time, eventually outcompeting native vegetation like grasses, sedges, and rushes. Lepidium also acts as a "salt pump", taking in salts from the soil via its roots and depositing them near the soil surface, altering soil salinity and essentially permanently altering the habitat. Lepidium is quickly becoming a dominant plant in many parts of the Marsh. Without control this plant will take over and change your habitat. Early detection and control are crucial in stopping the spread of Lepidium on your property.

Two other perennial non-native invasives on managed wetlands in Suisun are pampas grass (*Cortaderia selloana*) and Common Reed *Phragmites australis*. Phragmites can be native (uncommon and noninvasive) or non-native. The invasive Phragmites ("haplotype M"), strongly believed to be a non-native form indigenous to Eurasia, can aggressively invade wetlands (Saltonstall 2002). Both pampas grass and Phragmites can be controlled with Roundup® or Aquamaster (both glyphosate). Pampas grass can also be manually or mechanically removed; however, the rootstock must be dug up and removed as well to prevent re-sprouting.

Aquamaster can be either aerially or manually applied to Phragmites in early August when seed heads mature. Another option is to spray Phragmites, burn or mow the dead Phragmites stems and then spray regrowth again before discing it (Barthman-Thompson et al. 2007).



Several native plants can be invasive in managed wetlands. Dense stands of tules (*Scirpus acutus*) and cattails (*Typha spp*.) in ponds and sloughs can impede the flow of water. To control this problem, areas can be burned or disced, followed by herbicide application on new growth. Mowing can also control tules and cattails. Dead plant material resulting from either method should then be burned prior to fall flooding (Rollins 1981). When saltgrass (*Distichlis spicata)* becomes a dense mat, limiting more desirable plant growth, the pond may be burned, disced, or flooded for a prolonged period. If flooding alone is used, it may take several years before plant material has decomposed enough to allow growth of desirable plants. Saltgrass can also be controlled by spraying followed by burning or rough discing, spraying any regrowth, and then discing to prepare the seed bed for planting. Pickleweed can be considered an invasive plant and is best controlled by flooding, discing, or mowing close to the ground. Baltic rush (*Juncus balticus*) can also be considered invasive if stands become thick. One recommendation for rush control is to drag a ripper bar through the stand followed by fall burning (Rollins 1981).

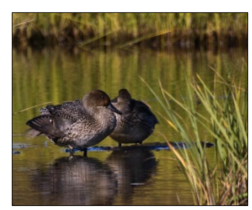
E.2.5 Native Species

Diked marshes can have characteristics and conditions similar to certain naturally occurring ecological communities, the main difference being a lack of salinity variability in the diked marshes. Salinity variability in tidal marshes promotes species diversity and helps maintain the native plant community. Periods of high salinity (drought years) followed by periods of low salinity (high precipitation years) tend to create conditions that favor rare plants and discourage species dominance (DWR 2001). In contrast, managed wetlands are managed to have little salinity variability that creates conditions where many rare plants are not able to compete well enough to survive (Barthman-Thompson et al. 2007). When lands are cut off from all tidal influence, they are susceptible to invasions by nonnative invasive species (DWR 2001).

In Suisun, growth of managed wetland plants must conform to a water management schedule. Water management schedules generally include flooding of ponds in September or October, circulating water (leaching) through November and December, and draining in January and February. Ponds may then be flooded again in March or April, circulated through May, and drained again by June 15^{th} (Barthman-Thompson et al. 2007). For a list of native Suisun Marsh vegetation please see **Appendix R**, an adaption of the 2005 Managed wetland conceptual model.

E.3 Managing Habitat Areas

E.3.1 Brood ponds (Figure 7)



Managing an area as a permanent pond will result in establishment of submergent vegetation such as sago pondweed and wigeon grass for food and invertebrate production. Tall emergents such as cattail and tule will also become established, providing cover in the pond (Rollins, 1981).

To create the appropriate conditions for certain desired plant species, pond water salinity must be maintained at low levels. Low salinities are achieved by exchanging high salinity pond water with the lower salinity channel water in the springtime. Water exchanges are most effective when there is high river flows and channel water salinity is low. Water exchanges are conducted as necessary to keep pond water salinity below salinity tolerance levels for desired plant species. In addition, ducklings are sensitive to salinity with potential thresholds for impairment above 5 ppt (9 mS/cm) and lethality above 15 ppt (25 mS/cm).

It is critical to establish stable water levels in brood ponds since waterfowl choose a nest site based on stability and availability of water (Owens and Black, 1990; Bruthwaite, 1982). Factors that trigger the breeding cycle (i.e. nest site selection, etc.) may operate so that young hatch at the time of maximal food production (Owens and Black, 1990).

E.3.2 Nesting requirements

On upland areas, a minimum of 25% of upland habitat should be managed as dense nesting habitat for resident breeding birds such as short-eared owls (*Asio flammeus*), northern harriers (*Circus cyaneus*), ducks, and ring-necked pheasants (*Phasianus colchicus*). A total of 25% of upland habitat should be managed for grazing and upland foraging wildlife species such as raptors and geese. If there are large blocks of uplands (at least five acres) cereal grains should be planted on a minimum of 10% of the total upland habitat in the fall (before December 1) to produce both nesting habitat and upland forage areas (Barthman-Thompson et al. 2007).

E.4 Plant Habitat Management

E.4.1 Mowing

Mowing is an effective method of creating open areas in the ponds and for setting back monocultures to allow diverse plant communities to develop. Mowing rather than discing allows seeds to remain above ground and available for birds and small mammals. Mowing temporarily prevents saltgrass, Baltic rush, and other perennials from building up and becoming too dense for other plant species to survive.

Mowing can be an effective habitat control measure for saltgrass, Baltic rush, and other perennials. Following mowing, saltgrass must be flooded with the water level six inches over the top of the plants to deprive the plants of oxygen. In areas where saltgrass is the dominant species, mowing alone will not give other plants the competitive advantage they need to become established. Mowing saltgrass without flooding may cause more vigorous growth than before mowing (Barthman-Thompson et al. 2007).

Ponds are mowed after August (usually in September (Rollins 1981) when ground nesting birds have fledged, and seeds have matured and settled in pond bottoms. Areas should be mowed in strips or by clearing the entire area around the pond. Leaving vegetated strips can appear more natural and provides cover for birds (SRCD 1998). There is no acreage limit on mowing.

E.4.2 Burning

Marsh management fires are used to improve marshland for wildlife habitat. Burning can aid in quickly replacing nutrients in the soil, remove undesirable seeds from the seed bank, remove excess plant material from the pond bottom to speed up the decaying process, and control undesirable plant species such as saltgrass, Baltic rush, and Phragmites. Burns can change a monotypic stand of vegetation into a diverse plant composition, creating healthier habitat (SRCD 1998).

Burning should not be required annually if management favors desirable plants. Burning should be needed approximately every three to five years as undesirable vegetation accumulates, or if there has been little or no management to control invasive vegetation species. Burning may be the only option even on properly managed ponds because Suisun soils are relatively soft, often rendering mechanical manipulation with heavy machinery inappropriate (SRCD pers. comm.).

Burning for invasive vegetation control requires caution. Control of invasive species is best achieved if an area is burned immediately before flooding. This will deprive the plants of oxygen and carbon dioxide and keep the plants from rejuvenating. Burning without a follow up flooding period or herbicide treatment can allow the undesirable plants to rebound, in some cases stronger than before.

The BAAQMD allows for controlled burns in the Suisun Marsh during the spring and fall. In the spring, burning typically occurs from March 1st to April 15th. In the fall, burning generally occurs from September 1st to October 15th. All marsh management fires must be certified by the DFW and require a Smoke Management Plan approved by the BAAQMD prior to burning. In addition, a local fire agency burn permit is required. After receiving permission to burn, it must be a permissive burn day and a burn allocation must be granted (based on weather conditions and the number of acres requested to be burned that day). Burn hours are from 10:00 a.m. to 3:00 p.m. (Barthman-Thompson et al. 2007).

In the fall, when soil conditions are dryer, it is advisable to burn only when the ditches have been charged and a firebreak has been disced around the perimeter of the burn for containment. Fires occurring on peat soil can be very difficult to extinguish. Springtime generally is the most effective time to burn. A spring burn will result in more robust vegetation growth with greater seed production in the fall, while fall burns may result in the removal of aboveground seed, which can be detrimental to the growth of desired species (SRCD 1998).

Permanent ponds can be drained once every five years, followed by burning or discing cattails and tules that have become dense. The ponds should then be disced or mowed in mid-summer when new growth is two feet high (Rollins 1981). Burning the same area two years in a row is prohibited. The land must be given a chance to revegetate and rejuvenate before it can be burned again. In the fall, total acreage allocation may range from zero to 300 acres per day and is limited to 100 acres per day on any property, or for pre-designated groups of properties. In the spring burning period, the total acreage allocation is limited to 600 acres per day. Burning is not allowed in tidal wetland areas (SRCD 1998).

E.4.3 Discing

Ponds may be disced for vegetation rejuvenation as discing can turn thick monotypic stands of vegetation into more diverse habitat. Discing prepares the seedbed by stimulating seed bank recruitment and removing layers of plant litter. Discing, following a burn, can kill plant roots by exposing them to the sun, and can increase the speed of nutrient recycling. Leaving the soil surface rough following discing can improve the effectiveness of leaching during the first year. The more surface area exposed to water, the potentially more effective the leach (SRCD 1998).

The most effective discing technique is cross discing. This technique involves making one pass across a field and then making a second pass at a ninety-degree angle to the first. Cross discing will effectively turn the soil and expose plant roots (SRCD 1998).

Caution should be used when discing certain plants. Perennial pepperweed and Phragmites need to be sprayed with an herbicide such as Round Up or Aquamaster prior to discing. These plants thrive on disturbed sites and discing may spread viable root segments and give them the competitive advantage needed to completely take over a disturbed site. Baltic rush will form a dense almost impenetrable mat below the shoots, and the area should be plowed first to allow the disc blade to penetrate the soil (SRCD 1998).

Discing vegetation may be a more effective thinning measure than mowing. However, discing the same area on a regular basis can cause soil subsidence of the pond bottom over time (Rollins 1981). Over discing can also break up the soil into very fine particles, which will form a hard, almost impenetrable, crust when it encounters water (Barthman-Thompson et al. 2007).

E.4.4 Spraying

The control of Phragmites (*Phragmites australis*) and perrenial pepperweed (*Lepidium latifolium*) are of major concern in the Suisun Marsh, and control efforts are best when conducted in coordination on both public and private lands.

Non-native *Phragmites* is originally from the Middle East, but it was introduced to the U.S. in the late 1800s and spread across the continent, flourishing across a wide range. It is a rhizomatous perennial grass that can grow up to 15 feet tall and reach densities over 180 stems per square meter (Saltonstall 2005; Gilbert et al. 2009a, 2009b), and it is one of the most aggressive invasive species in marsh ecosystems of North America (Bains et al. 2009). Phragmites creates an impenetrable area that impedes recreation, limits site access and views, crowds out native species, provides poor resources for wildlife, reduces movements, and creates a fire hazard (Hazelton et al. 2014, Kettenring et al. 2015).

Phragmites has taken over large areas of the Suisun Marsh and is increasing. Dead stems may account for 70% of the total *Phragmites* stalks present (Gilbert et al. 2009a, Gilbert unpublished data); thus, it creates a large fire hazard in the fall when the plant has senesced. Controlling *Phragmites* in the Marsh will improve public and environmental safety by reducing the fuel load it creates, decreasing the likelihood of the wetlands carrying larger fires resulting in economic and ecological losses.

Phragmites control of Suisun Marsh will best be accomplished through coordinated and strategic landscape management targeting areas of spread (Kettenring et al. 2015), incorporating monitoring to focus on key areas (Kettenring et al. 2016), and minimizing disturbance to the ecosystem.

The SRCD Lepidium Control Program will meet the goals of improving the habitat quality of managed wetlands by removing this highly invasive weed. This will in turn improve ecosystem function by allowing the soil to return to its normal condition, allowing native vegetation to grow. Chemical control (spraying) can be an effective method of control of invasive plant species, in combination with discing and burning of vegetation. Lepidium is most effectively treated by the herbicide Telar; however, it can also be controlled by the use of glyphosate (Roundup). SRCD has coordinated a very successful Lepidium spray control program to help provide spraying services and offset cost to landowners. More information is provided on SRCD Lepidium Program on the website (https://suisunrcd.org/programs/#pestweedcontrol). Spraying is done from a tank mounted to some sort of all-terrain vehicle, like a quad or an Argo, but can be done from a backpack set up as well. The type of spraying technique depends on the patch size of Lepidium; small patches can be hand sprayed using a backpack set up or hand sprayed from a larger tank mounted to an all-terrain vehicle. Larger patch sizes of Lepidium require the use of a boom mounted to the back of an all-terrain vehicle, so that larger areas may be sprayed.

F. References

Baginska, B., 2012 Suisun marsh TMDL for methylmercury, dissolved oxygen and nutrient biostimulation. San Francisco Bay Regional Water Quality Control Board. https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/suisunmarsh/SM_Project%20DefinitionPlan_Sep_2012_FinalDraft.pdf

Bains G, Sampath Kumar A, Rudrappa T, Alff E, Hanson TE, Bais HP. 2009. Native plant and microbial contributions to a negative plant-plant interaction. Plant Physiol. 151: 2145 – 2151. 10.1104/pp.109.146407.

Barthman-Thompson, L., Bruce, K., Estrella, S., Garrison, P., Haffner, C., Niceswanger, J., Van Klompenburg, G., and Wickland, B. 2007. Conceptual model for managed wetlands in Suisun Marsh.

Braithwaite, L.W. 1982. Ecological studies of the Black Swan. IV. The timing and success of breeding on two nearby lakes on the southern tablelands of New South Wales. Australian Wildlife Research 91: 261-275.

Brown, Sarah K. 2003. The Use of Molecular and Morphological Tools to determine if Salt Marsh Harvest Mice (Reithrodontomys raviventris) and Western Harvest Mice (Reithrodontomys megalotis) are Hybridizing. Masters Thesis, Cal Poly State University San Luis Obispo. 193pp.

Buffington, K.J., Dugger, B.D., Thorne, K.M., and Takekawa, J.Y. 2016. Statistical correction of lidar-derived digital elevation models with multispectral airborne imagery in tidal marshes. Rem. Sens. of Env. 186:616-625.

Buffington, K.J., Thorne, K.M., Takekawa, J.Y., Chappell, S., Swift, T., Feldheim, C., Squellati, A., and Mardock, D.K., 2019. LEAN-Corrected DEM for Suisun Marsh: U.S. Geological Survey data release, https://doi.org/10.5066/P97R4ES3.

Burns, Ed., M. Miller, J. Eadie. 2003. An Analysis of Food Habits of Green-winged Teal, Northern Pintails and Mallards Wintering in the Suisun Marsh to Develop Guidelines for Food Plant Management: A Report to the California Dept. of Water Resources and the U.S. Bureau of Reclamation. 66 pp.

CALFED Bay-Delta Program (CALFED). 1999. Multi-species conservation strategy. Species accounts for evaluated species technical appendix.

California Department of Water Resources (DWR). 2001. Comprehensive Review Suisun Marsh Monitoring Data 1985-1995. Environmental Services Office.

California Department of Water Resources (DWR). 2000. Suisun Marsh monitoring program reference guide. 2:1-122.

California Department of Water Resources (DWR). 1999. Suisun Marsh monitoring program reference guide version 1. The State of California. The Resources Agency Department of Water Resources Environmental Services Office. 1-80.

California Department of Water Resources (DWR). 1999 Suisun Marsh Preservation Agreement Amendment Three Biological Assessment. Sacramento, California.

California Department of Water Resources (DWR). August 2017. Supplemental Program Environmental Impact Report. Central Valley Flood Protection Plan. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-Planning-and-Studies/Central-Valley-Flood-Protection-Plan/Files/CVFPP-Updates/2017/PEIR-CVFPP2017Update-FinalSupplemental.pdf

California Natural Diversity Data Base (CNDDB). 2003. California Department of Fish and Game. Natural Heritage Division. Sacramento, CA.

Casazza, M.L. 1995. Habitat use and movements of northern pintails wintering in the Suisun Marsh, California. M.S. Thesis, California State University, Sacramento.

Central Valley Habitat Joint Venture (CVHJV). February 1990. Central Valley Habitat Joint Venture Implementation Plan: A Component of the North American Waterfowl Management Plan. California Waterfowl Association, Defenders of Wildlife, Ducks Unlimited, National Audubon Society, The Nature Conservancy, Waterfowl Habitat Owners Alliance, California Department of Fish and Game, Trust for Public Lands, and U.S. Fish and Wildlife Service.

Gilbert, J. M, L. Bennett, D. Jacobs, E. Slavik, R. Drouin, and B. Locke. 2009a. Testing the efficacy of grass select herbicides for controlling the invasive alien species Phragmites australis subsp. australis. Lake Erie Management Unit, Ontario Ministry of Natural Resources. OMNR #52527, ISBN 978-1-4435-0378-5.

Gilbert, J. M., L. Bennett, F. Letourneau, K. McLean, R. Drouin and B. Locke. 2009b. McLean Marsh Pilot Project: Managing the Invasive Alien Species Phragmites australis (common reed) in a Lake Erie coastal wetland, Rondeau Bay, Ontario. Lake Erie Management Unit, Ontario Ministry of Natural Resources. OMNR #52528, ISBN 978-1-4435-0379-2.

Goude, C., Tegelman, D., Edmondson, S., Chappell, S., Wilcox, C., Reed, R., McDonnell, B., Pacheco, V., Enright, C., Minn, K., Sung, J., Culberson, S., and Brad Tom. 2005. Suisun Marsh charter group levee conceptual model: state of knowledge. Habitat Management, Preservation, and Restoration Plan for Suisun Marsh. 4:1-24.

Hazelton, E.L.G., T. Mozdzer, D. Burdick, D.F. Whigham, and K.M. Kettenring. 2014. *Phragmites australis* management in the United States: 40 years of methods and outcomes. AoB Plants, plu001.

Kettenring, K.M., D.F. Whigham, E.L.G. Hazelton, S.K. Gallagher, and H.M. Baron. 2015. Biotic resistance, disturbance, and mode of colonization impact the invasion of a widespread, introduced wetland grass. *Ecological Applications*, 25: 466-480.

Kettenring, K.M., K.E. Mock, B. Zaman, and M. McKee. 2016. Life on the edge: reproductive mode and rate of invasive *Phragmites australis* patch expansion. *Biological Invasions*, 18: 2475-2495.

Kimmerer, W. 2004. Open water processes of the San Francisco Estuary: From physical forcing to biological responses. *San Francisco Estuary & Watershed Science*. 2 (1): Article 1. https://escholarship.org/uc/item/9bp499mv

Kwasny, D. C., Mike Wolder, and Craig R. Isola. 2004. Central Valley Joint Venture. Technical guide to best management practices for mosquito control in managed wetlands.

Leidy, R.A. 1984. Distribution and ecology of stream fishes in the San Francisco Bay drainage. Hilgardia 52(8):42.

Matern, S.A. L. Meng, P.B. Moyle. 1996. Trends in fish populations of Suisun Marsh, January 1995-December 1995. Annual report prepared for Contract B-59998. Sacramento (CA): California Department of Water Resources. 41 p.

Matern, S.A. L. Meng, P.B. Moyle. 1997. Trends in fish populations of Suisun Marsh, January 1996-December 1996. Annual report prepared for Contract B-09008. Sacramento (CA): California Department of Water Resources. 52 p.

Michny, Frank. 1979. Trends of Pintails Wintering in the Suisun Marsh California Based on an Analysis of 20 years of Aerial Surveys. U.S. Fish and Wildlife Service. Sacramento, California. 45 pp.

Mitsch, W. J. and J. G. Gosselink. 2000. The value of wetlands: importance of scale and landscape setting. Ecological Economics. 35:25-33.

Moyle P.B., 1995. Conservation of native freshwater fishes in the Mediterranean type climate of California, USA: a review. Biological Conservation 72: 271-280.

National Cooperative Soil Survey U.S.A. 2001. Suisun Series. https://soilseries.sc.egov.usda.gov/OSD_Docs/S/SUISUN.html

National Oceanic & Atmospheric Administration (NOAA). 2018. Tidelog 2019 Suisun Bay & Delta. Pacific Publishers.

Orr, R.T. 1939. Fall wanderings of clapper rails. Condor 41:151- 152.

Owens, M. and J.M. Black. 1990. Tertiary Level Biology: Waterfowl Ecology. New York, NY, USA.

Raabe, A., Wadsworth, R., Scammell-Tinling, J., Rodriguez, S., Cholodenko, L., Battistone, C., Nobriga, M. and Enos, C. 2010. Suisun Marsh Tidal Marsh and Aquatic Habitats Conceptual Model. Chapter 4: Species. Suisun Marsh Habitat Management, Restoration, and Preservation Plan.

Rollins, Glenn L. 1981. A Guide to Waterfowl Habitat Management in Suisun Marsh. California Department of Fish and Game.

Rollins, Glenn L. 1973. Relationships between soil salinity and the salinity of applied water in the Suisun Marsh of California. California Department of Fish and Game Quarterly. 59(1): 5-35.

Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of the common reed, Phragmites australis, into North America. Proceedings of the National Academy of Science 99:2445-2449.

Saltonstall, K., Burdicks, D., Miller, S., and Smith B. 2005. Native and non-native Phragmites: Challenges in identification, research, and management of the common reed. National Estuarine Research Reserve Technical Report Series: 2005.

San Francisco Bay Conservation & Development Commission (BCDC). Suisun Marsh Protection Plan. 1976. http://www.bcdc.ca.gov/plans/suisun_marsh#3

San Francisco Estuary Project (SFEP). 1992. Status and trends report on aquatic resources in the San Francisco Estuary. San Francisco Estuary Project. Public Report.

San Francisco Bay Regional Water Quality Control Board (SFRWQCB). 2018. Resolution No. R2-2018-0015. Amending the water quality control plan for the San Francisco Bay basin to establish water quality objectives and a total maximum daily load (TMDL) for dissolved oxygen in Suisun Marsh, to include Suisun Marsh in the San Francisco Bay mercury TMDL, and to make minor editorial revisions. https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/suisunmarsh/SM%20TMDL%20Resolution%20Signed.pdf

Siegel, S., P. Bachand, D. Gillenwater, S. Chappell, B. Wickland, O. Rocha, M. Stephenson, W. Heim, C. Enright, P. Moyle, P. Crain, B. Downing, B. Bergamaschi. 2011. Final evaluation memorandum, strategies for resolving low dissolved oxygen and methylmercury events in northern Suisun Marsh. Prepared for the State Water Resources Control Board, Sacramento, California. SWRCB Project Number 06-283-552-0. May. http://aquaticcommons.org/6470/1/FinalEvalMemo_MainRpt%2BAppA-G_SuisunLowDO-MeHg_1119_2011-0525%28low-res%29.pdf

Siegel, S., Enright, C., Toms, C., Enos, C., Sutherland, J. 2010. Suisun Marsh tidal marsh and aquatic habitats conceptual model. 1: Physical Processes. https://www.fws.gov/sacramento/outreach/2010/1029/Documents/Tidal_CM_Chapter_1_Phys_Proc.pdf

Smith, K.R., Barthman-Thompson, L.M., Estrella, S.K., Riley, M.K., Trombley, S.N., Rose, C.A., and Kelt, D.A. 2020. Demography of the salt marsh harvest mouse (Reithrodontomys raviventris halicoetes) and associated rodents in tidal and managed wetlands. Jrnl Mammal. 101(1):129-142.

State Water Resources Control Board (SWB). 1978. San Francisco Bay/Sacramento-San Joaquin Delta Estuary Water Quality Control Plan.

Stathem, M.J. and Sacks, B.N. 2019. Salta Marsh Harvest Mouse Landscape Genetics and Connectivity within the Suisun Bay Area Recovery Unit. Report to the California Dept. of Water Resources.

Suisun Marsh Charter Group. 2005. Levee Conceptual Model State of Knowledge. U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, National Oceanic and Atmospheric Administration Fisheries Services, Department of Fish and Game, Department of Water Resources, California Bay-Delta Authority, Suisun Resource Conservation District. https://www.fws.gov/sacramento/outreach/2010/10-29/Documents/Levee_Conceptual_Model.pdf

Suisun Resource Conservation District (SRCD) Suisun Marsh Management Program. September 1980. California Department of Fish and Game, California Department of Water Resources, San Francisco Bay Conservation District and Development Commission, County of Solano, Solano County Mosquito Abatement District, U.S. Fish and Wildlife Service, U.S. Soil Conservation Service, and U.S. Water and Power Resource Service.

Suisun Marsh Plan (SMP). EIR 2011/EIS 2014. Suisun Marsh habitat management, preservation, and restoration plan: final EIS/EIR. United State Department of the Interior, U.S. Fish and Wildlife Service, California Department of Fish and Game, and ICF International.

Suisun Resource Conservation District (SRCD). 1998. Individual Ownership Adaptive Management Habitat Plan.

U.S. Army Corps of Engineers (USACE). 2018. Regional General Permit 3 for the Suisun Marsh managed wetlands operations and maintenance project. https://suisunrcd.org/wp-content/uploads/2018/03/SPN-2012-00258_RGP3_2018_Signed-1.pdf

United States Department of Agriculture, Soil Conservation Service. 1975. Suisun Marsh Study of Solano County, California. Pp. 26-29.

U.S. Environmental Protection Agency. Improving water quality in Suisun Marsh. https://www.epa.gov/sfbay-delta/improving-water-quality-suisun-marsh

United States Fish and Wildlife Service (USFWS). 1981. Section 7 Determination, Suisun Marsh Management Study, Solano County, California. USFWS, Sacramento, California.

Wilber, S.R.. and R.E.Tomlinson. 1976. The literature of the western clapper rails. Wildlife Res. Rpt. No. 194, U.S. Fish Wildl. Ser., Washington, D.C.

G. Appendices

<u>Regulatory:</u>

History of Legislation & Administrative Actions within Suisun Marsh

Appendix A: Suisun Marsh Legislation, Protection Policies, and Plans

- **A.1: Suisun Marsh Preservation Act 1977**
- **A.2: BCDC Suisun Marsh Protection Plan**
- **A.3: Solano County Local Protection Program**
- **A.4: SCMAD Local Protection Program**
- **A.5: SRCD Local Protection Program**
- **A.6: DWR Suisun Marsh Plan of Protection EIR 1984**
- **A.7: Suisun Marsh Habitat Management, Preservation, and Restoration Plan EIR/EIS 2011, 2014**

Environmental Permitting and Compliance:

Appendix B: USACE Regional General Permit 3
Appendix C: SFBRWQCB RGP 3 401 Water Quality Certification
Appendix D: USACE Letter of Permission Suisun Marsh Dredging Permit
Appendix E: SFBRWQCB Dredging 401 Certification
Appendix F: NOAA Biological Opinion
Appendix G: USFWS Biological Opinion
Appendix H: DFW Incidental Take Permit

<u>Physical Considerations:</u>

Appendix I: Levee, Ditch, and Water Control Structure Specifications
Appendix J: Infrastructure Descriptions
Appendix K: Suisun Marsh Channel Water Salinities
Appendix L: Soils and Soil Salinities
Appendix M: Drainage Infrastructure and Modeling Report 2018

<u>Biological Considerations:</u>

Appendix N: Managed Wetland Conceptual Model
Appendix O: Example Water Management Schedules
Appendix P: Water Quality Improvement Best Management Practices
Appendix Q: SCMAD Wetlands Best Management Practices
Appendix R: Key Wetland Plants and Growth Requirements

H. Glossary

BAAQMD	Bay Area Air Quality Management District
BCDC	San Francisco Bay Area Conservation and Development Commission
BDP	San Francisco/Sacramento-San Joaquin Delta Estuary Water Quality Control Plan (Bay Delta Plan)
BMPs	Best Management Practices
BO	Biological Opinion/Assessment
CEQA	California Environmental Quality Act
CVHJV	Central Valley Habitat Joint Venture
CVP	Central Valley Project
CWA	California Waterfowl Association
DFW	California Department of Fish and Wildlife
DO	Dissolved Oxygen
DRM	Department of Resource Management
DSC	Delta Stewardship Council
DU	Ducks Unlimited
DWR	California Department of Water Resources
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Ecologically Significant Unit
GIWA	Grizzly Island Wildlife Area
LAFCO	Solano County Local Agency Formation Commission
LiDAR	Light Detection and Ranging
LOP	U.S. Army Corps of Engineers Letter of Permission
LPP	Local Protection Program
MDP	San Francisco Bay Conservation and Development Commission Marsh Development Permit
MeHg	Methylmercury
MIDS	Morrow Island Distribution System
MWA	Managed Wetland Assessment
NAIP	National Agriculture Imagery Program
NAVD 88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration Fisheries
NRCS	National Resources Conservation Service
Outfall	Goodyear Slough Outfall
Plan	Individual Ownership Adaptive Habitat Management Plan
PPSM	Plan of Protection for the Suisun Marsh (DWR) 1984
RD	Reclamation District
RGP 3	Regional General Permit 3
RMA	Resource Management Associates
RRDS	Roaring River Distribution System
RWQCB	Regional Water Quality Control Board
SCMAD	Solano County Mosquito Abatement District
SFRWQCB	San Francisco Bay Regional Water Quality Control Board
SLC	State Lands Commission
SWB	State Water Resources Control Board (State Water Board)
SLT	Solano Land Trust
SMHM	Salt Marsh Harvest Mouse
SMMP	Suisun Marsh Management Program (SRCD's LPP)
SMP	The Suisun Marsh Habitat Management, Preservation, and Restoration Plan Environmental Impact Report (EIR) 2011/Environmental Impact Statement (EIS) 2014
SMPA 1974	Nejedly-Bagley-Z'berg Suisun Marsh Preservation Act of 1974
SMPA 1977	Suisun Marsh Preservation Act of 1977: PRC Sec 29000-29612
SMPA 1987	Suisun Marsh Preservation Agreement
SMPA 2015	Revised Suisun Marsh Preservation Agreement
SMPP	Suisun Marsh Protection Plan (1976)
SMSCG	Suisun Marsh Salinity Control Gate
SRCD	Suisun Resource Conservation District
SWP	State Water Project
SWRCB	State Water Resources Control Board
The Marsh	Suisun Marsh
TMDL	Total maximum daily load
USACE	United States Army Corps of Engineers

USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WSS	Web Soil Survey