Appendix J- Managed Wetland Infrastructure

The managed wetlands of Suisun Marsh consist of a series of exterior and interior levees, exterior and interior water control structures, ditch and water conveyance systems, drainage pumps and water intake fishscreens. This infrastructure is crucial to the control of water and the movement of water across the managed wetlands to promote managed wetland habitat and prevents Suisun Marsh from being a brackish tidal marsh. This infrastructure requires annual inspections and general maintenance to ensure their integrity remains viable. Through SRCD property owners can follow permitting requirements for maintenance and replacement of water control structures through the Suisun Resource Conservation District's U.S. Army Corps of Engineers (USACE) Regional General Maintenance Permit 3 (RGP#3) for the primary and secondary management area of the Suisun Marsh. Annual maintenance can be highly variable in terms of cost, extent, and permitting. But this infrastructure is critical for managed wetland habitat management.

Exterior Levees

The foundation of the managed wetlands are the exterior levees that protect the individual management areas in Suisun Marsh. This infrastructure was built along slough channels and dredger cuts that separate the tidal sloughs and bays from the managed wetland areas. The levees range from 7.0-9.0 feet above mean low tide marks. A typical cross section consists of a levee top (crown) with a 6.0-12.0 foot cap and a 2:1 slopes along the exterior and interior of the levee profile down to the toe of the levee.

Routine maintenance is important for exterior levees which are consistently impacted by wave action, king high tide overtopping events, wind fetch/wave action, boat wake disturbance, and rodent damage. Maintenance can come in many forms with permitted activities that include obtaining material for recontouring the levee crown and backslope from the adjacent managed wetlands or the exterior slough channels (dredging), levee coring with mechanical equipment, and protecting troubled areas with bulkheads or large quarry rock (rip-rap) where it is permitted.

Bulkheads

Bulkheads are built to stabilize and strengthen levees exposed to highly energetic water flows or wave energy. These structures typically are installed near water control structures and prevent the erosion of soils at the toe of the levee and ditch banks. Bulkheads can also be installed along areas where heavy equipment and other exterior levee protection measures (rip-rap) are not cost effective or feasible. Exterior work is done at low tide and does not involve any excavation of sediments from the exterior slough. In-water work is done by hand (unbolting the old boards and/or bolting a new structure together), and generally a ground crew lifts the old boards out of the water and lowers the new boards into place. A new bulkhead may be constructed to strengthen newly excavated sections of levee. Bulkheads can be constructed from wood or vinyl or metal sheetpile. This activity generally would be implemented in the summer months.

Existing Riprap on Exterior Levees

Riprap consists of field stone or rough un-hewn quarry stone that is large enough to remain in place against standard wave and wind action on the exterior levees. Rip-rap was suggested as an effective way to protect levees from the erosion resulting from wave action, boat traffic, and high wind fetch areas. A component of the SMP is to provide levee system integrity as integral to the continuation of managed wetlands and the success of created tidal wetlands (EIR/EIS 2011).

Riprap is replaced on the tidal side of exterior levees in the minimum amount necessary for bank stabilization. Riprap will be placed on exterior levee banks only in those areas with existing riprap. Those areas that receive direct wave impacts historically have been fortified with riprap and require periodic maintenance. Riprap is placed on the tidal side of exterior levees using a long reach excavator that is located on the levee crown, or by barge with a dragline or clamshell dredge. The barge method is used less frequently as it requires greater channel widths and depths and is more expensive. Riprap generally is replaced during July through September (EIR/EIS 2011).

New Riprap in Exterior Levees

The levee system in Suisun Marsh is continually under the pressure of tidal stage, wind fetch, eroding currents, and boat-wake damage. With sea level rise and climate change these pressures are expected to increase. Over time, protective vegetated berms and levee toes erode and expose the levee foundation to the have been treated, and their continued maintenance is described above. This activity addresses those areas that currently do not have riprap but that may be determined in the future to require such treatment. This new activity would place up to 6,000 linear feet of new riprap over the 30- year plan period on the side slopes of interior water conveyance ditches and up to 2,000 linear feet of new riprap on the side slopes of exterior levees on newly exposed areas not previously riprapped. (This is in addition to the replacement of riprap described above.) No more than 200 linear feet of new riprap would be placed annually. Riprap is placed on the levee using a long-reach excavator or a clamshell or dragline dredge. Placement of riprap would be done from June through September. Riprap materials are transported to the site with a 10-wheel dump truck with a capacity of 16 cy or by barge with a 400 cubic-yard capacity. For interior levees, this activity is needed occasionally where the velocity of water flowing through an exterior water control structure causes scouring eddies and bank erosion of inter-levee toes. New riprap would be placed only when it has been determined that the specific conditions of each site would not support other types of erosion control.

<u>Riprap would be applied only under the following circumstances</u>:

- Levees exposed to channel velocities that are too high to support vegetation. Depending on soil type, it may be possible for levee material to with stand short durations that exceed 6 fps.

- Channel depth on the face of the levee slope is deeper than 3 feet below MTL and the levee slope is steeper than 3:1 (H:V); riprap would be applied to reduce erosion potential without consideration for incorporation of vegetation.
- Levee face typically is exposed to vessel wakes year-round and not located in a 5-mph zone; riprap would be applied in area where erosion persists.
- Fetch length exceeds 1,000 feet in the direction of the predominant southwest to southeast winds during high water conditions (e.g., winter storms, spring tides) or prevailing winds during all other times (typically from the west); riprap would be applied to the upper slope of the levee to dissipate wind driven waves and reduce erosion potential.

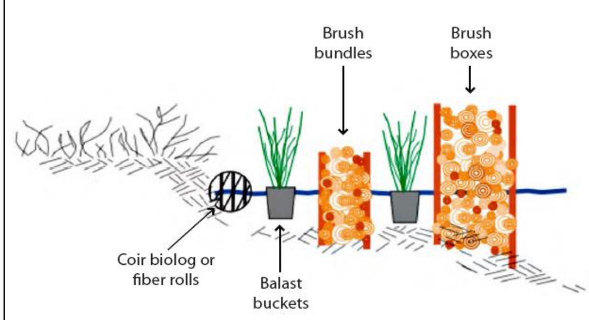
Where new riprap is placed, integrative vegetation also would be applied where it is biologically appropriate.

If new riprap is placed on either interior or exterior levees, BMPs would be implemented to reduce the environmental effect as described below in the Environmental Commitments section (EIS/EIR 2011).

Alternative Bank Protection (Brush Boxes and Ballast Buckets)

SRCD was required to employ levee maintenance methods that do not use riprap. Alternative forms of levee bank protection for both exterior and interior levees include brush boxes, biotechnical wave dissipaters, and vegetation. Brush boxes use natural materials and native plants for capturing sediment to stabilize and protect exterior levees while also providing fish habitat (Figure X).

Figure X. Composite Brush Works/Ballast Buckets



The installations generally are done during July through September. Brush boxes, brush bundles, and ballast buckets are placed below the mean high-water mark and anchored with tree stakes. Brush boxes and brush bundles are generally dead branches that are staked into the ground or wrapped in coconut fiber (Figure 2-2).

Ballast buckets are organic, biodegradable buckets planted with native wetland species such as tule, three-corner bulrush, and Baltic rush. As the technology is developed further, alternative materials or installation methods may be used. The installation of brush boxes and ballast buckets does not involve any in-water work because all work is done at low tide. This work is done entirely by hand, reducing the sedimentation that can occur with mechanical work. After the build-up of sediment and the growth of native plants over time, the exterior levee would be stabilized and protected from further erosion, and habitat would be established for fish and the macroinvertebrates on which they feed. Integrated vegetation solutions are desirable to provide low maintenance "living" bank protection and wave-energy dissipation.

Applications of these solutions are limited by the local channel velocities and depth, wind fetch, and exposure to wake. If the tidal hydraulic regime is suitable for the establishment of vegetation capable of resisting high channel velocities and wave energy, vegetation will be incorporated into the erosion protection design. This would reduce the future maintenance costs of erosion protection (EIR/EIS 2011). Criteria used to determine the appropriateness of vegetation by itself or in combination of riprap for each site can be found in **Appendix H**.

Interior Levees

Interior levees are embankments that allow for management of water inside exterior levees on the managed wetland. The interior levees are not exposed to tidal action. The purpose of interior levees is to isolate specific areas within the managed wetland to provide those areas with independent water control. The crown of these levees is normally less than 4 feet above pond bottom with a top width of 10 feet (Barthman-Thompson 2005).

The maintenance and improvement of the interior levee system is an integral component of water control within managed wetlands. Properly functioning interior levees and water control structures can aide in moving water efficiently. Construction of new interior levees within large wetland ponds would improve of flooding and draining capabilities. Ponds divided into smaller cells (i.e. 50 to 100 acres) could flood and drain faster than larger ponds. The ability to flood and drain quickly has been shown to help reduce the need for aerial mosquito abatement (Haffner and Bruce 2004). Smaller cells within managed wetland ponds also allow wetland managers to create multiple habitat types in one pond. Currently, construction of new interior levees is not allowed by the U.S. Army Corps of Engineers Regional General Permit as it is considered fill of wetlands (Barthman-Thompson 2005).

Riprap for Interior Levees

Riprap is replaced on interior levees in the minimum amount necessary for bank stabilization and in areas around water control structures where water flow and eddies erode the ditch bank and interior levee toe. Riprap will be placed on interior levee banks only in those areas with existing riprap. Riprap is placed on the interior levees using a long-reach excavator that is located on the levee crown. Approximately 300 feet of riprap can be placed per day. Riprap generally is replaced during July through September (Barthman-Thompson 2005).

Exterior/interior Water Control Structures

The purpose of water control structures is to admit, distribute, and remove water from the managed wetland at the discretion of the water manager. 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 (Rollins 1981). Water control structures should be adequate in size, number, type, and location to permit flooding and draining of a managed wetland within a 30-day period. Water control structures (pipes) are constructed by various materials such as High-Density Polyethylene (HDPE), corrugated metal, fiberglass, or plastic. The attached water control structures (gates) are typically constructed from stainless steel, cast iron, plastic, and HDPE.

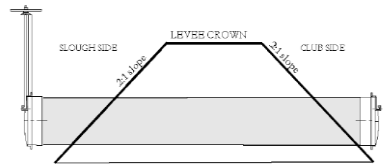


Figure X. Typical Exterior levee section for a flood gate

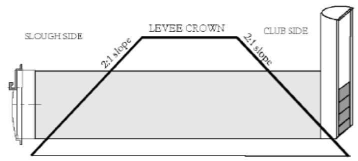


Figure X. Typical Exterior levee section for a drain gate

The six most commonly used water control structures used for flooding and drainage of ponds are culverts, flap gates, screw/flap gates, screw gates, flashboard risers, and flashboard flap gates.

Culverts are corrugated steel or plastic pipes placed in interior levee for the purpose of conveying water from one side of the levee to the other (Rollins 1981). (Figures X and X)

Water Control Structures (Pipes)

Some managed wetlands in the Suisun Marsh still use corrugated metal pipes (CMP) to regulate water levels within their ponds. Smooth wall plastic pipe (HDPE) is the current material utilized on most of the pipe replacements occurring within the Marsh. Smooth wall plastic pipes have several advantages over the existing CMP:

1.) Lifespan – smooth wall plastic pipes last up to 25-30 years, whereas a CMP has an expected lifespan of around 10 years

2.) Flow efficiency – Smooth wall plastic pipes have more efficient water flow due to reduced drag between the water and the inner pipe wall

3.) Reduced maintenance – longer lasting smooth wall plastic pipe (coupled with stainless steel components) reduces the need for constant replacement and/or upgrading, thereby reducing long-term maintenance costs on the structure. Marsh management is dependent upon water control structures. It does not pay to cut financial corners when purchasing new structures.

Installing or replacing pipe for existing flood, drain or dual-purpose gates

The replacement of an exterior water control structure (pipe, gates, stubs, and couplers) that is used to either flood or drain managed wetlands. There are no restrictions on the size of a drain gate that can be installed or replaced. For flood gates and dual-purpose gates (flood and drain) that divert water from tidal sloughs, however, the overall capacity of the diversion for that parcel may not be enlarged. In the past, water control structures typically were constructed of corrugated metal pipe. Because of the corrosive environment of the Marsh, these pipes often begin leaking and fail in 8 to 15 years. If an exterior pipe leaks, habitat management and maintenance activities would be compromised as a result of uncontrollable flooding of the managed wetland. Therefore, metal pipes typically are replaced with high-density polyethylene (HDPE) pipes.

When a pipe is replaced, a new pipe and appurtenant structures are assembled on the crown of the levee with the appropriate control structure components attached to each end of the pipe. A trench is excavated in the exterior levee over the old pipe, and the pipe is removed. All replacement activity is completed in one low tide. Replacement pipes typically are placed in the same location as the existing structure, the trench is backfilled, and the backfilled material is compacted. Either a dozer or an excavator is used to excavate the trench, and generally an excavator is used to install the replacement pipe. The backfill material is compacted with a dozer and/or excavator.

Replacement of the pipes takes approximately 4 days and generally would be done March through September. The first day is mobilization of equipment and materials, the second day is assembly and preparation for installation, the third day is installation, and the fourth day is demobilization and site clean-up. If a new drainpipe is required, it would be installed at a location where discharge channels already exist, or exterior levees have minimal vegetation. The new structure is assembled on the crown of the levee, usually with a flap gate or screw flap on the outside and flashboard riser or screw gate on the inside. Installing a new drainpipe requires the same types of equipment and takes the same amount of time as replacing an old drainpipe.

New or enlarged intake structures must be screened, which makes it impractical to increase flooding capability due to the high cost of screening. Only 50 new exterior water control structures may be installed in the Marsh annually. This number is generally adequate with the advent of new plastic materials that extend the life of water control structures. These new materials do add significantly to material costs but extend the life of structures to the point that rotational replacement is no longer necessary on most parcels. The management capabilities of many landowners could be improved by adding new flood structures to speed flood time. The SRCD recommends that every parcel should be able to flood in 10 days and drain in 20 days to maximize habitat quality (Rollins, 1981).

Water Control Structures (Gates)

The managed wetlands of Suisun Marsh implement a variety of water control gate structures on their interior and exterior water control structures to flood, drain, circulate, and convey water across the managed wetlands. These gates all have varying levels of benefit and function, and aid in water control and movement through the managed wetlands.

Flap gates
Flap gates are hinged metal covers affixed to the end of culverts (pipes). Flap gates are designed to allow the free flow of water in one direction and prevent back flow in the opposite direction. The water pressure against the flap controls the rate of flow through the gate. (Figure X)

Figure XX. Simple flap gate.

Combo gate
Screw/flap gates (dual-purpose gates) are the most versatile and common gates. The cover or flap is attached to a movable frame that may be raised and lowered by means of a threaded screw-shaft connected to the support structure. Screw/flap gates are predominantly installed on the exterior side of levees but can be utilized on the interior side as well. Screw/flaps are typically used in combination with flap gates and flashboard risers (described below) located on the inboard side. The lowered position of the gate functions as a drain with the inboard riser controlling the water level in the pond. In the raised position the gate permits water to enter the pond during high tides. These gates are recommended in situations where gates must serve the dual function of inlet and outlet automatically. (Figure X)

Figure XX. Slide flap gate.

Canal gate (screw gate)
Slide gates (screw gates) consist of an unhinged sheet of metal attached to a movable frame. The frame is raised and lowered manually by means of a threaded screw-shaft connected to a support structure. Slide gates are generally used in combination with flashboard risers. Unlike screw/flap gates, they do not operate automatically with the tide and require an operator to regulate the direction of flow. Slide gates are usually used as inlet or outlet structures with a flap gate on the opposite end of the culvert. (Figure X)

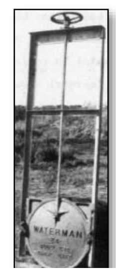


Figure X. Slide gate.

Flashboard Riser
Flashboard risers consist of a length of corrugated metal or HDPE material with a metal framed rectangle and a length of pipe attached that can be affixed to a water control structure. Wooden boards are inserted one on top of the other into the grooved frame, thus preventing water, except that which spills over them, from entering the culvert. The number of boards placed in the riser controls the level of pond water. Flashboard risers are very effective for controlling pond depth and facilitating efficient circulation. (Figure X)

Figure X. Flashboard riser.

Flashboard Riser Flap Gate
Flashboard Riser Flaps are water control structures that are typically build out of stainless steel or corrosive resistant materials. The structure is build to slide into the rectangular metal frame of a flashboard riser and rest on the bottom of a riser. A cable or rope is attached to a hinged portion of the gate and can be lifted to facilitate drainage and circulation through these water control structures. This reduces the work to remove boards from the flashboard riser boxes and allow the ideal water level controls to remain unmoved while water can drain at a faster rate.

Water Conveyance (Swales/Primary ditches/Secondary ditches/"V" ditches)

Primary ditches, also known as main ditches, supply ditches, or circulation ditches, form a network of aqueducts which usually originate and terminate at exterior levees (Rollins 1981). The purpose of the primary ditch system is to allow a managed pond to be flooded and drained within a 30-day period (SRCD 1980). Primary ditches convey water to and from a major water source to flood, circulate, and drain managed wetlands. These ditches should be large enough (12-20 feet wide) to flood the entire property within 10 days, drain within 20 days, and deep enough (3-3.5 feet deep from pond bottom elevation) to drain secondary ditches increasing the effectiveness of leach cycles (SRCD 1998). (Figure A-1)

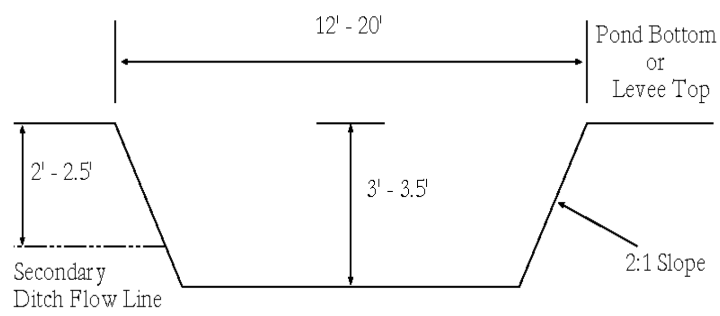


Figure A-1. Cross Section of Primary Ditch

Secondary ditches, usually used on larger properties, supply the pond with enough water to flood up within 10 days, drain within 20 days, and are usually 6-10 feet wide and 2-2.5 feet deep (SRCD 1998). (Figure A-2) These ditches connect "V" ditches to primary ditches and ultimately empty out to the water control structure (SRCD 1998).

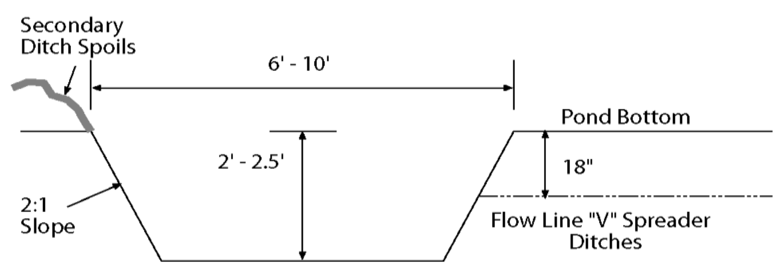


Figure A-2. Cross Section of Secondary Ditch

"V" ditches also known as spreader ditches are used to hasten the drainage of isolated low spots in ponds, enhance leaching of pond soils distant from primary ditches, and to improve circulation (Rollins 1981). "V" ditches connect secondary ditches to primary ditches for more effective draining of low areas of the pond where pooling water leads to soil salt depositing on the soil surface (SRCD 1998). "V" ditches are at least 18 inches wide and 18 inches below the adjacent ground elevation (Rollins 1981). (Figure A-3)

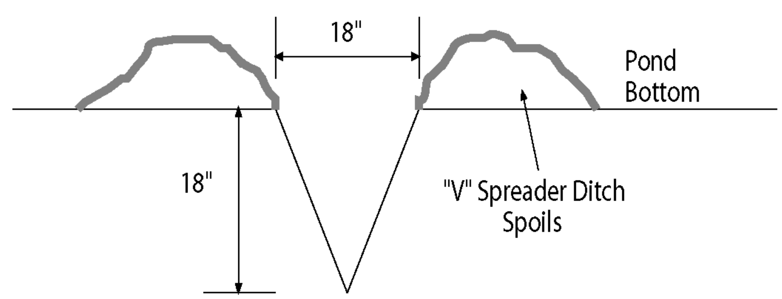


Figure A-3. Cross Section "V" Spreader Ditch

The maintenance of ditches primarily involves removing obstructions caused by vegetation, debris, and siltation. Maintenance is scheduled to maintain the ability to use the ditches to flood and drain the pond in 30 days or less (SRCD 1980).

Pumps
Permanent or portable water pumps provide managers with the opportunity for intensive water management through the proper timing of flooding and dewatering of ponds during critical growth periods of wetland plants (DFG 1988). Pumps also enable a 30-day flood and drain capability designed to produce desirable wetland vegetation (DFG 1988) and enhance leaching cycles through proper water control.
The ability of a managed wetland to efficiently flood and drain is dependent on the location in the marsh, the pond bottom elevation, along with water control facilities. If a managed wetland has a relatively high mean pond elevation it is difficult to tidally flood and conversely a wetland with relatively low mean pond bottom elevation is difficult to drain. To solve this problem, managers use pumps to completely drain areas of ponds that cannot drain at low tide.

Pumps also allow managers to flood their wetlands with lower salinity water than passive flooding methods alone because of increased flexibility to intake water throughout the tidal cycle (Biological Assessment 1999). Intake pumps fitted with detachable fish screens compliant with CDFW, U.S. Fish and Wildlife Service (USFWS) delta smelt, and National Marine Fisheries Service (NMFS) salmonid criteria can be used year-round (Biological Assessment 1999).

Permanent pumps are electrical, requiring costly electricity to run. Due to normal wear accelerated by the corrosive saline environment periodic maintenance is required. Maintenance includes checking the oiler reservoir for the shaft bearing, checking oil level in bearing reservoir, lube bearings, and conduct a pump efficiency test to determine how much electricity is used per volume of water pumped. If pump efficiency is low, then the impeller may be worn and need replacing. The above maintenance is completed depending on the frequency of pump use and may be required at least weekly, if not daily.

Landowners use portable air-cooled diesel pumps due, in part, to remote isolated locations without electricity. Portable pumps are placed on the levee crowns with collapsible aluminum pipes across the levee for water discharge (DWR 1999). These pumps have a longer life than electrical pumps as they are removed from the brackish water when not in use and therefore are not subject to the corrosive effects of brackish water year-round. A drawback of portable pumps is the cost of diesel fuel and its delivery.

Fish Screens
Estuarine fish such as splittail, delta smelt, Chinook salmon, stag horn sculpin, and three-spined stickleback occur in tidal marsh channels of Suisun. Intake restrictions are in place to reduce or eliminate fish entrainment. Additional fish screens would also reduce the potential for entrainment as well as enhance manager’s capability to maintain quality habitats.

A fish-screening program and diversion restrictions are in place to address potential impacts to anadromous and special status fish in the Suisun Marsh. In the long term, these measures could assist in the recovery of special status fish (winter and spring run Chinook salmon, delta smelt, and Sacramento splittail), potentially avoid future listings of currently unlisted fish, and will insure maintenance of seasonal wetland habitat. In the short term, these measures will immediately reduce the potential for fish entrainment and allow for optimal management of seasonal wetlands upon which so many species of wildlife depend. Consistent with the ecosystem approach, the viability of wetlands (at no serious risk to fish species) will insure that habitat will be protected for all wetland-dependent species.

Without screening, diversion restrictions interfere with optimal wetland management. The high cost of fish screen installation has made it difficult to find funds to install more screens. In the 2002 CALFED PSP, a proposal to build more fish screens in the Suisun Marsh was not funded. In the absence of more fish screens or reduced species closures, habitat quality and quantity in the managed wetlands of the Suisun Marsh many suffer.

An alternative option to adding more fish screens would be to investigate the effects of entrainment. It is currently unknown how many fish are returned to the sloughs rather than being stranded in the managed wetlands. If restricted species are returned to the sloughs intact, current intake restrictions might need to be reevaluated and possibly relaxed.