ADAPTIVE HABITAT MANAGEMENT PLAN TEMPLATE

Suisun Resource Conservation District

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Preface

The goal of this template is to provide an overview and broad background information, describe existing conditions and operations on managed wetlands in the Suisun Marsh, and to provide wetland management guidance to Suisun Marsh landowners.

The existing physical and biological conditions in the Suisun Marsh affecting wetland management strategies drive management, which in turn determines the resulting habitat, and ultimately the species that will utilize that habitat. Wetland habitat managers must continuously adaptively manage their properties in order to achieve management objectives.

Since existing conditions will change continually, new data will be identified and then be incorporated into this template as the new existing state of knowledge. This template will serve as the starting point for development of management decisions on managed wetlands in the Suisun Marsh. However, it is not meant to be the sum total of all Suisun Marsh wetland management knowledge. Attached to this document are a number of Appendices and References that will guide the inquisitive wetland manager to a wealth of additional detailed information related to sustaining and enhancing the wetland habitat values of the Suisun Marsh.

Introduction

The Suisun Resource Conservation District (SRCD) encompasses the wetland and open water areas of the Suisun Marsh. It includes 52,000 acres of diked wetlands, 6,300 acres tidal wetlands, and 30,000 acres of bays and sloughs, all protected by the Suisun Marsh Preservation Act of 1977. The diked wetlands and most of the upland grasses are managed for desirable food, cover, and nesting habitat for resident and migratory wildlife. The complexity (including water salinity, soil salinity, tides, and water delivery schedules) of this system requires managers to try and create conditions favorable to numerous species. Wetlands improvement takes effort, knowledge, and a plan of action. Landowners who are unaware of all aspects of wetland management are not being as effective as they could be in maintaining and improving wildlife habitat and enhancing Marsh values and functions. Broadening the range of knowledge and creating a document that can be applied to wetlands management programs will improve the quality of the managed wetlands in the Marsh.

This management plan template presents up-to-date information about brackish marsh management designed to benefit waterfowl as well as fish, wildlife, and plants living in or migrating through the Suisun Marsh. The plan is necessary to achieve greater species diversity while complying with certain restrictions and criteria set forth by regulatory agencies.

Timely information is key to managing a brackish, diked wetland more effectively. This management plan template is a “living document”, meaning that it will be revised periodically to incorporate new scientific understanding and changes in the regulatory and physical environment of the Marsh. This template also facilitates a site-specific element for each managed wetland unit that will be updated on an annual basis to document ongoing management changes in water control infrastructure and facilities improvements. This gives SRCD the flexibility to distribute new or updated material as the information becomes available and to keep management plans current and useful.

History of the Suisun Marsh

The Suisun Marsh is one of the largest remaining contiguous brackish marshes in the US. Located about 35 miles northeast of San Francisco in southern Solano County, it provides habitat for numerous species of plants, fish, and wildlife. Historically, the Suisun Marsh was comprised of a wide plain of saltgrass (*Distichlis spicata*) associations supporting a large number of brackish (halophytic) marsh plant species and included about 68,000 acres of tidal wetlands. From the mid-1880s to the early 1900s, over 90 percent of these wetlands were reclaimed for agriculture. Agricultural production and success was limited due to increasing salinity in the Suisun Bay/Marsh region. Most of the levees originally constructed for agricultural reclamation now form part of the infrastructure for managing water levels in seasonal, non-tidal (managed) wetlands.

Suisun's levee and water control infrastructure has been used to create seasonal wetland habitat since the late 1800's. Today, ninety percent of the wetlands in the Suisun Marsh are diked and managed as food, cover, and nesting habitat for wildlife. Seasonal wetland management strategies in the Suisun Marsh are based on waterfowl food habits studies conducted in the Suisun Marsh during the late 1960's and early 1970's. One study (George 1965) indicated that seeds from alkali bulrush (*Scirpus maritimus*), fat hen (*Atriplex triangularis*), and brass buttons (*Cotula coronopifolia*) provided the bulk of the wintering waterfowl food supply and a recent study (Burns 2004) has shown that waterfowl seed selection may be even more diverse than previously thought. The George study was the basis for other studies (Mall 1969; Rollins 1973) of habitat conditions necessary to produce the above seed bearing plants. These studies concluded that plant communities in the Suisun Marsh are controlled primarily by the depth and duration of soil submergence and secondarily by the concentration of salts in the root zone.

As part of the Pacific Flyway, the Suisun Marsh hosts thousands of native and migratory waterfowl every year. Market hunting of waterfowl in the Suisun Marsh began around 1859 (Arnold 1996) and effectively controlled most of the hunting grounds for the next 20 years. In 1871, the Chamberlain family obtained a patent from the State of California for some land on the western side of the Marsh between Cordelia and Suisun sloughs. This was one of the prime market hunting sites in the Marsh and was leased to the market hunters. Shortly after leasing the property, the market hunters started taking wealthy San Francisco businessmen on guided hunts to help offset the cost of the lease. This began the waterfowl sport hunting tradition in the Marsh, which is still evident today. In early 1878, construction began on a railroad link from Fairfield to Benicia through the western side of the Marsh. For the next 35 years, the railroad poured an endless amount of rock and millions of board feet of lumber onto this line in an effort to keep the tracks above water. Often crews would work all day to stabilize a section of track only to discover it had sunk back below the water's surface over night. Two stations were set up, one at Teal pond and the other at Cygnus pond, allowing access to prime hunting areas, all of which were no more than a half mile from the tracks. This led to the first official private duck club on the west side of the Marsh, the Hardland Club, in 1888.

The California Department of Fish and Game purchased Joice Island in 1927, making the island the first state-owned wildlife refuge. In 1948, the State purchased 8,600 acres on Grizzly Island, forming the Grizzly Island Waterfowl Management Area, to offset waterfowl depredation in the rice lands of the Central Valley. The goal was to provide an alternate site for waterfowl away from the productive agricultural lands of the Central Valley.

The Suisun Soil Conservation District was formed in 1963 (later renamed the Suisun Resource Conservation District) by several Marsh landowners. In 1964 the Suisun Conservation Fund was established to protect the Suisun Marsh and to insure that the Marsh will be protected from encroachment of developing towns and industry.

The establishment of the Central Valley Project (CVP), and later the State Water Project (SWP), resulted in increased exports from Central Valley rivers and the Delta. Prior to this, the managed wetlands within Suisun Marsh were effectively managed to provide high quality habitat for the wintering waterfowl and other migratory birds of the Pacific Flyway. The State Water Resources Control Board (SWRCB) recognized the function and importance of this area to the health of these populations of birds as well as local flora and fauna. Land uses in the Marsh were recognized as meeting the State Water Code definition of beneficial uses, and as such required appropriate protection from deleterious effects to their water supply.

The Suisun Marsh Preservation Act of 1974 required the Bay Conservation and Development Commission (BCDC) to prepare a Suisun Marsh Protection Plan (SMPP). The SMPP and its Fish and Wildlife Element were formally adopted as part of the Suisun Marsh Preservation Act of 1977, which repealed the 1974 Act and implemented the designated policies in the SMPP. The SMPP protected these lands in perpetuity, although governance of land use was split between the primary Marsh and the secondary Marsh. The primary Marsh is regulated by the BCDC and Solano County regulates the secondary Marsh with oversight and ultimate authority remaining with BCDC.

In 1978, the SWRCB issued Water Right Decision 1485 (D-1485), which established conditions on the water rights permits of the U.S. Bureau of Reclamation (USBR) for the CVP and of the California Department of Water Resources (DWR) for the SWP. The D-1485 (replaced in 1999 by D-1641) required the development of a plan that included appropriate environmental documentation, a water quality monitoring network, physical facilities, operation and management procedures, and assurance to restore and maintain Suisun Marsh as a brackish water Marsh capable of producing high quality feed and habitat for waterfowl and other Marsh related wildlife when suitable management practices are followed. Construction of the initial facilities (Roaring River Distribution System, the Morrow Island Distribution System, and the Goodyear Slough Outfall Facility) in the Suisun Marsh were necessary to comply with the requirements of D-1485, the Plan of Protection for the Suisun Marsh and accompanying Environmental Impact Report (EIR) that was completed in February 1984. The Plan of Protection presented an approach to mitigate the effects of the CVP and SWP on the Suisun Marsh.

In March 1987, SRCD, DFG, USBR and DWR negotiations culminated in the signing of the Suisun Marsh Preservation Agreement (SMPA). Concurrently, DFG, DWR, and USBR also signed the Suisun Marsh Monitoring Agreement and the Suisun Marsh Mitigation Agreement. The primary objective of the SMPA was to assure that a dependable water supply was maintained to mitigate the adverse effects on the Marsh of the CVP and SWP and a portion of adverse effects of other upstream diversions. This agreement also defines Marsh water quality standards similar to D-1485, with the exception of variance in these standards in a series of dry and critical water years.

The Delta smelt *(Hypomesus tranpacificus)* was listed as endangered in March 1993, Sacramento Splittail *(Pogonichthys macrslepidotus)* was proposed for Federal listing (although subsequent Court challenges succeeded in halting the listing), and winter-run Chinook salmon *(Oncorhynchus tshawytscha)* was listed as threatened in November 1990 and the two water supply projects (CVP and SWP) were identified as the principal causes of the decline. Additionally, other factors were at work because of the declining state of the biological resources of the Delta. D-1485 was deemed by the Environmental Protection Agency (EPA) under the Clean Water Act, as not protective of the beneficial uses of the Delta and promulgated its own standards. This precipitated negotiations between State of California agencies and Federal counterpart agencies addressing these problems and working toward a solution that would meet the needs of all water users, Urban, Environmental and Agriculture. Negotiations with these entities led to the signing of the Bay Delta Accord in December of 1995 and the establishment of CALFED.

In 2005, the original SMPA was revised by agreement between the original signatories. This revision provides additional funding of specified management activities, provides for operational changes and channel water salinity standards, and deletes the requirements for constructing additional large water control facilities in the Marsh. The revised SMPA recognizes the beneficial effects to managed wetlands of increased delta outflows and effective Suisun Marsh Salinity Control Gate (SMSCG) operations. The objectives of the original agreement and this amendment are to provide facilities or actions that protect the Marsh while mitigating for Marsh impacts from water project operations such as the State Water Project and the Central Valley Water Project and other upstream diversions on Marsh channel water salinity.

The objectives of the revised SMPA are to provide funds for wetland managers in impacted areas of the Marsh to re-establish a diverse plant assemblage and return soil salinities to levels characteristic of Marsh brackish soils, to maintain soil salinities within natural ranges, to improve wildlife habitat on managed wetlands, and to broaden mitigation activities emphasizing management and restoration projects. The signing of the revised SMPA and the implementation of the programs listed above will assist landowners of managed wetlands in achieving soil salinities for improved growth of forage for waterfowl and other wildlife on managed wetlands.

SRCD Management Program

In 1977, the passage of Assembly Bill 1717 required the SRCD to prepare a management program designed to preserve, protect, and enhance the plant and wildlife communities within the primary management area of the Suisun Marsh. This program (called the SRCD Management Program to Preserve, Protect, and Enhance the Plant and Wildlife Communities within the Primary Management Area of the Suisun Marsh) was completed in 1980. This document has served as a long-range protection plan and is certified by the CA Department of Fish and Game (CDF&G) and the SF Bay Conservation and development Commission (BCDC). Under the provisions of AB1717, the BCDC has been given primary state responsibility for the implementation of the protection plan.

Wetland managers in Suisun Marsh must take into account factors such as soil water salinities, depth and duration of soil submergence, and applied water salinity to prevent the accumulation of soil salts above natural levels outlined by the US Department of Agriculture (USDA) Soil Conservation Service (1977) for Suisun Marsh soils.

In the early 1980's the Soil Conservation Service prepared management plans for each of the 160 privately managed wetlands in the Suisun Marsh. These plans recommended leaching soil salts from the root zone by performing one or more leach cycles (rapidly flooding and draining the wetlands to one foot below pond bottom). These water management schedules recommended rigid dates for water application, drainage, and water levels within the managed ponds.

In 1999, agency managers with primary responsibility for actions in Suisun Marsh developed a Charter to guide the development of the Habitat Management, Preservation, and Restoration Plan for Suisun Marsh (Plan) that would protect and enhance Pacific Flyway and existing wildlife values, endangered species, and water-project supply quality. The Charter Group Principal members include the Suisun Resource Conservation District (SRCD), U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NOAA Fisheries), U.S. Bureau of Reclamation (BOR), California Department of Fish and Game (DFG), California Department of Water Resources (DWR), and California Bay-Delta Authority (CBDA). The Charter Group has also consulted other participating agencies, including the San Francisco Bay Conservation and Development Commission (BCDC), U.S. Army Corps of Engineers (COE), Regional Water Quality Control Board (RWQCB), and US Environmental Protection Agency (EPA) in developing this Plan.

The Plan objectives will be supported with the development of a programmatic EIS/EIR (PEIR/PEIS), which will contain certain project-specific activities such as the RGP 3 renewal and will be described and analyzed at a high level of detail. When complete, the Plan will guide ongoing operations in managed wetlands and recovery actions for listed species in the Marsh. The Charter Group intends to ensure that the Plan is consistent with the Suisun Marsh Preservation Act.

Managed Wetland Maintenance Regulatory Requirements

Along with the CA Department of Fish and Game, the Suisun Resource Conservation District holds the U.S. Army Corps of Engineers Regional General Maintenance Permit 3 (file # 24215N) for the primary management area of the Suisun Marsh. This permit allows landowners represented by SRCD to conduct normal maintenance activities in the Primary Management Area. This permit has many restrictions and special conditions that protect and minimize impact to species and their habitats. To ensure landowner compliance with these permit conditions, each landowner is required to submit an annual work plan to SRCD for review and 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 and be a maintenance or enhancement activity that will not negatively impact the wetlands. No work is permitted in the tidal areas of the Marsh except replacing riprap in areas of previously existing riprap and water control gate replacement, unless an individual Army Corps of Engineers permit is obtained.

The landowner must file for an individual U.S. Army Corps of Engineers permit for any work that is **not covered** under the existing permit, such as dredging in the bays, slough or exterior channels, installing new flood pipes, or placing new riprap. The individual Army Corps of Engineers permit must comply with all other state and federal agencies regulation and permitting requirements. A list of the regulatory agencies that review or issue permits are:

- National Marine Fisheries Service
- U.S. Fish and Wildlife Service
- Department of Fish & Game 1603 Permit
- San Francisco Bay Conservation Development Commission Permit
- Regional Water Quality Control Board Certification
- State Water Quality Control Board Certification
- Environmental Protection Agency
- State Lands Commission Permit

Regulatory Restrictions

Many government agencies have jurisdiction over the Suisun Marsh (Marsh) at the federal, State, and local levels. Regulations restricting management activities affect management and therefore habitat composition and quality on managed wetlands. There are many regulations affecting management of wetlands in Suisun. The most notable regulatory action affecting the Marsh is the Suisun Marsh Preservation Act (SMPA) passed by the California Legislature in 1977. This Act was created to protect the Suisun marshland and it's upland habitats from development. An integral part of the Act is the Suisun Marsh Protection Plan, developed by the San Francisco Bay Conservation and Development Commission (BCDC). The plan sets forth policies on a variety of Suisun Marsh issues such as environmental protection, water quality, development, transportation, and recreation. BCDC works in partnership with federal, state, county, and local agencies. Appendix A discusses effects of regulatory actions on management of seasonal wetlands covered by the USACE and other regulatory agencies.

There are routine maintenance activities in the Marsh that are conducted on an annual basis. The SRCD and DFG jointly hold a U.S. Army Corps of Engineers (USACE) Regional General Permit #3 File Number 24215N (RGP #3) for routine maintenance on managed wetlands. Appendix B discusses primary water control structures used on managed wetlands in the Marsh that are maintained under RGP #3. Some activities conducted in the Marsh are not covered by the RGP #3 and need to be individually permitted as discussed briefly below.

The SMPA divides the Marsh into the "primary management area" (tidal areas, managed and seasonal wetlands) within which BCDC issues development permits. The "secondary management area" consists of upland grassland areas within which Solano County issues permits, which can be appealed to BCDC. BCDC permits are not needed for carrying out activities that are specified by a property's individual management plan or undertaking routine repair or replacement work on existing structures and facilities. However, any new development or activity within a property that is not specified in an individual management plan needs a marsh development permit. This would include new structures, new exterior or interior levees or channels, importation and deposition of fill materials from outside the property, and exterior levee work that is not consistent with the SRCD's standards. Appendix C discusses the effects of regulatory actions on the management of seasonal wetlands that are subject to or exempt from a BCDC Permit.

How Managed Wetlands Work

Marsh management and the water control facilities that manipulate the timing, duration, and depth of flooding play a significant role in determining Suisun Marsh wetland plant communities. Wetland managers use various structures such as levees, ditches, water control structures, controllable topography, pumps, and fish screens to meet management objectives. A Guide to Waterfowl Habitat Management in the Suisun Marsh (Rollins, 1981) was developed as part of the Suisun Marsh Management Plan. Due to increased regulatory restrictions over the past 20 years, SRCD has developed 11 updated water management schedules (SRCD, 1998) to assist wetland property owners and managers. These schedules should be considered guidelines because site-specific factors and endangered species closures vary in different regions of the Marsh in different water years.

Most wetland managers in the Suisun Marsh begin flooding their wetlands around October 1 in preparation for the fall migration of waterfowl. When possible, wetland managers of the Suisun 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. The wetlands are drained or circulated at low tide when the water elevation in the diked wetland 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 eight to twelve inches. After initial flood-up, water is diverted from adjacent sloughs, circulated, and then drained while maintaining water at eight to twelve inches deep. Compared to the initial flood-up period, relatively small amounts of water are exchanged between the sloughs and the ponds during circulation. Water circulation maintains water quality and prevents stagnant areas from developing. Circulation also helps prevent the increase of pond water salinity from evaporative loss and helps maintain natural soil salinities.

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

Habitat Improvements – Wetland Maintenance

The goals of wetland maintenance and habitat improvement are to attract waterfowl desirable to hunters in the Suisun Marsh, provide wintering waterfowl food and habitat, provide breeding habitat for resident waterfowl and ground nesting birds, and to preserve open space while maintaining hunting opportunities and experiences. It is assumed that managing wetlands to maximize waterfowl food plant quantity and diversity will maximize wintering waterfowl numbers in Suisun. The ability to manage water is the key to achieving managed wetland goals. Water managers must continuously adaptively manage their properties in order to achieve management objectives.

Land managers use vegetation manipulation, in conjunction with water management, as a tool to create a mosaic of habitats desirable to waterfowl species. Vegetation manipulation may include, but is not limited to, planting, herbicide treatment, flooding, burning, discing, and mowing.

Since 1977, the SRCD and the CDFG have jointly held a Regional General Permit (RGP) that allows maintenance activities within the primary management area of the Suisun Marsh. There are twenty-one approved work activities in the current RGP

Wetland maintenance and habitat improvement in Suisun relies on the following principles: Hydrologic change influences plant community composition and structure, thereby affecting the availability of waterfowl food (Fredrickson and Laubhan 1994). The quality, abundance and availability of resources, as well as spatial arrangement of different wetland types that provide such components, are critical factors that determine abundance and biodiversity of wetland wildlife (Fredrickson and Laubhan 1994).

Wetland managers can have the greatest effect on food resources and resulting wildlife use using these principles. Diverse wetland types and their spatial arrangement in the region determine the level of wildlife use. Dynamic wetlands supply a variety of food resources that allow waterfowl to feed selectively and to obtain nutritionally adequate diets from a variety of sites (Fredrickson and Reid 1988). In Suisun it is the diversity of habitats and the variety of foods they produce that attract up to 28% of the wintering waterfowl in California and many resident waterfowl.

Wetland managers maintain and improve local upland areas for resident breeding and nesting waterfowl where appropriate. Upland fields in the Suisun Marsh (specifically Grizzly Island Wildlife Area) are productive mallard nesting areas (McLandress et. al. 1996). Current management strategies maintain and enhance waterfowl nesting and brood habitats to promote local waterfowl production. More than 60% of the mallards harvested in California originate from breeding areas in California. Factors limiting mallard numbers in California are related to the quantity and quality of mallard nesting and brood rearing habitats (California Waterfowl Association, 2003).

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.

Wetland maintenance and habitat improvement can also create essential breeding habitat for shorebirds. Breeding shorebirds nest in a wide range of habitat from unvegetated wetland flats to moderately tall, dense upland grasses. For many breeding shorebirds, landscape juxtaposition of habitats is important. Temporary ponds are important early in reproduction, whereas seasonal, semi-permanent, and brackish wetlands provide foraging habitat throughout nesting and brood rearing (Eldridge 1992). Spring drawdowns practiced by Suisun Marsh wetland managers in conjunction with upland areas provide ideal foraging conditions for migrating shorebirds.

Managed wetlands and associated upland areas provide habitat for many mammal species. Most of the common mammals found in the Suisun 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.

In addition to benefiting wildlife, Suisun Marsh managed wetlands provide benefits to the surrounding community. Hunters spend approximately 50,000 hunter days each waterfowl season in Suisun Marsh. Specifically on public lands, hunts for waterfowl, pheasant, junior waterfowl, junior pheasant, elk, pig, rabbit, and falconry total 11,232 hunter days. Nature study, bird watching, and photography are recreational pursuits that have been increasing in the past few years. It is estimated that some 19,500 recreational use days are spent on public lands in the Marsh annually engaging in these activities. (pers. comm. Grizzly Island Wildlife Area 2002)

Despite challenges and constraints such as aging facilities, threatened and endangered species regulations, subsidence, mosquito abatement, and salinity issues, managed wetlands in Suisun Marsh provide a valuable resource for both wildlife and people.

Habitat Improvements – Water Control

SRCD has developed 11 water management schedule guidelines to assist wetland property owners and managers. These schedules are intended as guidelines because site-specific factors will influence actual management decisions made to reach the objectives for the property, and because water management schedules will change for different regions in the Marsh and for different water years.

Factors which influence the selection of the yearly water management schedule for an individual property are: 1) wildlife habitat management objectives, 2) physical management constraints, 3) the annual influence of environmental constraints, and 4) regulatory restrictions on wetland maintenance and water diversion activities in the Suisun Marsh. For those properties with individual units that have isolated water control systems, the selection of two or three different water management schedules for one piece of property may be possible. Location in the Marsh dictates what, if any, regulatory restrictions a property is affected by. For example, the northwest portion of the Suisun Marsh, on Cordelia Slough, is unaffected by endangered fish species closures; Montezuma Slough is affected by all closures; the northeast corner above Nurse Slough is under Chinook salmon restrictions but not under Delta smelt restrictions; and the Grizzly Bay and Honker Bay properties are under Delta smelt restrictions but not under Chinook salmon restrictions (Appendix H).

Factors determining what plants can grow on a property include the east-west and north-south salinity gradients; length soil is submerged; soil salinity; water depth; and salinity of applied water. For example, the southwest properties, nearest the ocean, have higher channel water salinity than properties in the southeast near Collinsville, where salinity is reduced due to Sacramento and San Joaquin River flows. The stream flows from Suisun Creek, Green Valley Creek, and Denverton Creek can create seasonally fresher channel conditions in the northern Marsh.

There are two main types of water salinity: applied water salinity (salinity of the source of flood or circulation water) and soil water salinity (water salinity in the soil). 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 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 fall flood up (September and October), salts on or near the surface of the soil are dissolved 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 mixing (circulation) of pond water with slough water continually removes the more saline pond water while replacing it with less saline slough water (DWR 2001). Rainfall mixing with pond water also serves to keep pond salinity down. The United States Department of Agriculture (USDA) (1977) stated that appropriate circulation of pond water and leaching of soil salts prevents increases in soil water salinity above natural levels for Suisun 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, evaporating, and concentrating those salts (DWR 2001). Overall, pond water salinity values tend to be 5-10 mS/cm greater than that of the applied water.

Habitat Improvements – Physical Manipulation

Burning:

The Regional Air Quality Control Board allows for controlled burns in the Suisun Marsh during the spring and fall. In the spring, burning typically occurs from the first of February to the end of April and can extend to June 30th during wet water years. The fall burn period typically runs from September 1st to October 15th. The first of September start date is only for the properties involved in the early flood program. All other properties must wait until September 15th before beginning to burn. During a fall burn, all fires should have a fire break disked around the perimeter of the burn for containment and it is a good idea to wait until the ditches have been fully charged. The high peat content of Suisun Marsh soils makes underground fires a constant threat. 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, and with a higher soil moisture content there is less chance of a peat fire. Fall burns will generally result in the removal of seeds from the pond area, reducing the seed bank of both desirable and undesirable plants. Fall burning may also result in the increased production of undesirable plant species.

Fire can be an important management technique. Burning can be an effective way to quickly replace 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*. Control of these species is best achieved if burned just prior to a flood-up period. The most effective kill occurs when the pond is immediately flooded over the unburned stalks. This will deprive the plants of oxygen and carbon dioxide and keep the plants from rejuvenating. Burning without a follow up flooding period can allow the undesirable plants to rebound, in some cases stronger than before.

Peat soils can burn and peat fires are difficult to extinguish. A controlled burn may ignite peat soils and do significant damage to levees if allowed to continue burning.

The burn should be performed into the wind. This will result in a hotter fire and a better kill of denser stands of vegetation. If the fire is allowed to burn with the wind then the flames will only burn through the upper canopy of the vegetation and not effectively kill or stress the plants. Burns and other management techniques that disturb an area are important because they can change a monotypic stand of vegetation into a diverse plant composition, creating healthier habitat.

Prior to burning the landowner needs to complete a Smoke Management Plan, which is required by the Bay Area Air Quality Management District (BAAQMD). This plan is first reviewed by the Department of Fish and Game before being forwarded to BAAQMD for final approval. Once the Smoke Management Plan is approved and returned to the landowner, the landowner must obtain a burn permit from the Suisun Fire Protection District. The day before the planned burn the landowner needs to contact BAAQMD to request a burn allocation. On the day of the burn the landowner needs to contact the BAAQMD to confirm that it is a burn day and to receive a burn acreage allocation. Finally, the landowner must call the Suisun Fire Protection District and inform them of the intent to burn. All fires should be lit after 10:00 a.m. and before 3:00 p.m.; the lighting of fires before and after these times is prohibited. 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 (properties in the same hundred series of numbers). In the spring burning period, the total acreage allocation is limited to 600 acres per day.

Discing:

Discing is limited to one fifth of a property per year. Discing aids in the preparation of seedbeds for artificial planting and natural succession. Discing can open up thick monotypic stands of vegetation, and change the overall vegetative composition of the pond. 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 is exposed to water, the potentially more effective the leach.

Cross discing is thought to be the most effective discing technique. This 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 the roots to the air.

The discing of certain plants needs to be carefully monitored. Some plants can reproduce from the chopped up pieces of roots so discing can increase production of pest species. *Lepidium* and *Phragmites* need to be sprayed with an herbicide such as Telar, RoundUp, or Rodeo prior to discing. These plants thrive on disturbed sites and discing may give them the competitive advantage needed to completely take over. Baltic rush will form a tough, dense mat below the shoots, and the area should be plowed first to allow the disc blade to penetrate the soil.

Over discing can sometimes do more harm than good. Over discing can break up the soil into very fine particles, which will form a hard, almost impenetrable, crust when it comes in contact with water. Discing may also cause subsidence by increasing the exposure of soils to the atmosphere. The more surface area is exposed to oxygen, the potentially higher the rate of oxidation. Pond bottom discing should be delayed as late as possible prior to flooding because flooding will counteract oxidation by shielding soils from exposure to the atmosphere.

Mowing:

Mowing is an effective method of creating open areas in the pond and for setting back monocultures to allow the formation of diverse plant communities. Mowing should be carried out by either cutting the vegetation in strips or by clearing the entire area around the pond. Mowing random strips into the vegetation will make the pond look more natural and there will be cover left for the birds to hide and get out of the wind. When large areas are mowed, wave action sometimes discourages birds from landing in these unsheltered areas.

Mowing should be done after August to prevent the destruction or disturbance of ground nesting birds. This will also allow seed maturation to take place and allow seed set in the pond bottom.

Mowing can also be an effective habitat control measure for saltgrass, baltic rush and other perennials. These plants can be drowned, and stands can be reduced if completely flooded after mowing. The water needs to be approximately 6" over the top of the saltgrass to prohibit it from obtaining oxygen. In areas where saltgrass is the dominant species, mowing alone will not give other plants the competitive edge they need to become established. Generally if saltgrass is mowed and not followed by flooding it will rebound denser then before.

Habitat management:

Resting islands are an important part of a pond that provide refuge to terrestrial species such as the salt marsh harvest mouse, shallow areas for shorebirds, and resting areas for waterfowl. These islands are low rises that are vegetated, about 1" below to 6" above water level, but in areas that wildlife have a clear field of vision for predators. These islands provide refuge and give waterfowl places to dry off and sleep. The other function of these islands is for nesting. Small mammals, shorebirds and waterfowl utilize islands for nesting and to avoid predation from mammalian predators. The best place to have a nesting island is a couple hundred yards from shore and if there is more than one island they should be spaced apart for better protection against predation.

Loafing ponds are typically wetland areas that are left undisturbed. Wildlife needs access to areas without disturbance from people or activity. These areas provide refuge for birds and mammals and will enable them to establish use patterns on the property. Established use patterns will help the property hold more birds and also create flight patterns over the property, from resting and feeding areas into these undisturbed loafing areas. Loafing areas and resting ponds are typically associated with each other.

Permanent ponds are very important to broods, molting waterfowl, and shorebirds. If managed correctly, emergent vegetation (30% - 70% of the total pond area) will provide predator shelter for birds. Emergent vegetation also provides high densities of invertebrates that are rich in protein and are the number one food item of ducklings and shorebirds. Cattail, tules, sago pondweed, and widgeon grass are the typical food plants found in permanent ponds. Permanent ponds need to be drained every three to five years to control carp populations and to reset the vegetative composition (control tule and cattail growth, allow decomposition of vegetative mats of submergent plants such as sago pondweed and widgeon grass) so the ponds are not choked off with vegetation. Usually these areas are provided through water depth manipulation. Deep areas of the ponds do not allow emergent vegetation to grow so these areas remain as open water habitat.

Ducklings do not have the ability to regulate the salt content in their bodies for the first ten days after hatching. The passage of salt into their bodies through the water can deform and even kill them. For survival, they require brood water salinity of less than 17 mS /cm. If the brood water provided is saltier than 17 mS /cm, the pond should be freshened by adding lower salinity channel water. If that is not possible, the pond should be drained to discourage ducklings from using the pond. Saline toxicity can also occur in ditches. Drain the ditches completely or monitor the salinity in the ditches so toxicity to ducklings does not occur.

The disadvantages to permanent ponds are carp infestations, botulism, and levee maintenance from muskrat damage. Carp will forage on the vegetation, dislodge plants, and cloud the water preventing light from penetrating. This will reduce the amount of vegetation and deplete the source of food for ducklings. Permanent ponds should maintain high circulation rates to discourage algal blooms and to ensure a healthy invertebrate population, thereby preventing the outbreak of botulism.

Typical ground nesters in the Suisun Marsh include mallards, pintail, gadwall, cinnamon teal, northern shovelers, short-eared owls, pheasants and Northern harriers. Waterfowl nests sites can be up to 1 mile from water. Annual grasses 18 inches or higher such as rye and brome provide good nesting areas. Secondary plant species such as vetch and fathen mixed with annual grasses provide excellent nesting areas, cover, and protection from predators. Vetch is a legume that has vine-like tendrils that discourage mammalian predators from walking through dense nesting areas and is thick enough to provide a good canopy to provide cover from avian predators. Vetch also provides residual cover in mid to late summer when plants are dying and dense green vegetation is sparse.

Perennial grasses like Harding Grass, Tall Wheatgrass, and Perla Grass are important upland plant species that grow in clumps and are used for food, escape, and nesting cover by waterfowl and other wildlife species. These need little management once established. Occasional mowing, discing, or burning may be required to maintain the fields in an early successional stage for these plants to thrive.

Invasive Plant Species Control

Both native and non-native plants can be considered invasive, depending upon the desired habitat. Non-native invasives 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 effective tools for invasive species control.

One of the most problematic non-natives in Suisun Marsh is *Lepidium latifolium* (perennial pepperweed). *Lepidium* invades both upland and wetland areas, including tidal zones where spraying is generally not permitted. SRCD has observed good success using Telar® to control *Lepidium* populations. In spring to early summer, plants are sprayed and disced to allow planting of upland seed. Discing is recommended only after a complete kill is accomplished by spraying.

Two other perennial non-native invasives on managed wetlands in Suisun are pampas grass (*Cortaderia selloana*) and *Phragmites australis*. *Phragmites* can be native (uncommon and noninvasive) or non-native. The invasive *Phragmites*, 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 resprouting. 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 spray regrowth again before discing it.

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. 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).

There are also annual non-native invasive species on Suisun managed wetlands, such as cocklebur (*Xanthium strumarium*) and bristly ox-tongue (*Picris echioides*). One method for controlling these species is to flood managed ponds to capacity for six weeks or more (DFG 2003a).

Water Quality Considerations

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. 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 dissolved oxygen (DO) events in small, dead-end sloughs adjacent to managed wetlands.

In an unpublished paper dated October 18, 2004, Schroeter and Moyle present data documenting low DO events in sloughs. Low DO events may be associated with dark to black water being discharged from managed wetlands. This observation had led the authors to believe that discharges from managed wetlands have caused the observed events. Low DO events coincide with fall flood up discharge activities when temperatures are high, circulation rate is low, and there is a large amount of dead broad-leaved vegetation on the pond bottom.

Low DO events have been associated with black water smelling of sulfides. U.C. Davis field researchers have noted dead fish and invertebrates in these areas resulting in concern for local and migratory fish populations. Impacts to other wildlife species have not been noted.

Acid sulfate reactions in soils high in iron result in the build up of sulfuric acid in the soil (Appendix D). Only certain types of iron rich soils are prone to this process. These soils can become acidic enough to be toxic to plants resulting in bare patches in ponds. Typical wetland management may exacerbate the condition when ponds are flooded, drained, and dried causing oxidation and reduction of soils. (DWR 2001)

A multi-agency study found that dabbling ducks did not avoid ponds with red water (USGS 1999). However, once ponds develop bare patches, waterfowl use would be expected to decrease.

SRCD Assistance

The signing of the revised Suisun Marsh Preservation Agreement (SMPA) has made funds available from the Department of Water Resources (DWR) and United States Bureau of Reclamation (USBR) for the Water Manager Program and Portable Pump Program. This program is designed to function as a cooperative service between SRCD and the private landowners of the Suisun Marsh. The water managers will provide technical support to landowners and assist in the implementation of yearly management strategies as outlined in the Individual Ownership Adaptive Management Habitat Plans (IOAMHP). The program will have three biologists in charge of the Water Manager Program.

Here is a partial list of services provided by the SRCD Water Manager Program:

- Assist in implementation of yearly management strategies as outlined in the Individual Ownership Adaptive Management Habitat Plans and agreed to by the landowners.

- Promote and encourage wetland management activities, including flooding, draining and circulation, so that they occur at the appropriate critical times of the year to produce desired wildlife habitats.

- Provide technical support in the field, answering questions and educating landowners on beneficial management techniques, the protection and enhancement of endangered species habitat, management of water application, and providing new scientific information pertaining to common management activities.

- Supervise and coordinate the portable pump program to ensure proper maintenance and operation of the pumps.

- Assist landowners in planning yearly maintenance and enhancement projects.

- Assist landowners in filling out the USACE yearly maintenance permit application.

- Annually update the Individual Ownership Adaptive Management Habitat Plans.

- Activities may include assisting DFG on water management of state owned property, assisting in yearly SMHM, CCR surveys, and inspections of levees during storms to identify damages and assist in flood fight coordination.

Because of the low elevations of some clubs, the need for pumping drain water was identified as an option to improve the quality of Suisun Marsh managed wetland habitats. The pumps would be used for drainage of managed seasonal wetlands into adjacent waterways throughout Suisun Marsh. This program would allow wetland managers to better control water levels and maintain appropriate water management during critical wetland plant growth periods.

These pumps could be used year-round for effective habitat management to assist with draining seasonal wetlands, but the primary use would be drainage during the late winter and spring when habitat management and maintenance of soil salts in the root zone is most critical. An exception of use would be in the locations of known low dissolved oxygen including Boynton and Peytonia Sloughs. These areas are adjacent to higher elevation wetlands, thus pumps would not be needed.

The WHIP (Wildlife Habitat Improvement Program) is an upland seed program that promotes nesting habitat for ground nesting birds (i.e. waterfowl, pheasants, etc.). The seed is a mixture of carefully selected plant species that provides the proper mosaic for optimal nesting efforts and wildlife use in our upland areas. The seed is strictly designed for the dry upland areas (even during flood up). Seed is bought in 50lb sacks for about $1/lb. The recommended application rate is 20 lb./acre.

The SRCD has limited equipment to aid in management of properties. Currently the SRCD has 1 large seeder, 2 electric ATV seeders, and drip torches that landowners are allowed to use free of charge. Other equipment available for a nominal rental fee is a 24x24 v-ditcher, 55-gallon spray rig, air compressor, and a boom truck w/operator.

Appendix A

Regulatory Requirements

A-1 U.S. ARMY CORPS OF ENGINEERS (USACE)

The USACE provides a Regional General Permit (RGP), administered the Suisun Resource Conservation District (SRCD) and California Department of Fish and Game (DFG), which allows maintenance activities such as ditch cleaning, levee coring, and installation of water control structures within the managed wetlands of the Suisun Marsh. The USACE also provides alternate permits for activities that are not covered under the RGP such as dredging (not permitted under RGP #) and dock maintenance.

The current RGP (File Number 24215N) authorizes landowners to conduct approved work activities and place fill in wetlands subject to USACE jurisdiction. This permit limits the time of year work can be done, how much work (volume) can be done, when/how much water may be taken into a property, what may be done with excavated native material, where riprap can be placed for bank protection, the installation of new flood structures, and also places twelve additional conditions (see page 5 of RGP #3) on the ability of landowners to work on their properties in the Marsh. It also requires the SRCD/DFG to administer a gate-monitoring program during fish closures required by NMFS/NOAA.

Volume restrictions may prevent landowners from doing all the work they need to do in a given work season. Below is a list of RGP #3 restrictions and how they affect landowner management strategies in the Marsh:

1) Work in interior ditches includes excavation from existing primary, secondary, and spreader V-ditches ditches or excavation to create new primary, secondary, and spreader V-ditches. Annual excavation volumes are limited; therefore landowners often must clean ditches on a rotational basis. This can add to the cost of equipment mobilization. Excavated material must be side cast and used for an authorized activity, or removed to an area outside of USACE jurisdiction (also adds cost).

2) Work on levees includes the placement of approved materials on the crown or sides of interior levees and the crown or landward side of exterior levees. Annual material placement volumes are limited; therefore landowners often must repair levees on a rotational basis. In emergency cases under Regional General Permit #5 (File Number 28218S) such as a levee breach, special permission must be granted by the USACE to exceed volume limitations. Delays in USACE approval allow damage to progress and therefore increase repair costs to the landowner.

   Also included in this category are levee coring (generally not necessary in large volumes), road maintenance (usually the 5,000 cubic yard limit is adequate), and replacement of riprap. Riprap must be approved material and may only be placed where riprap had previously existed. This restriction is especially burdensome because without riprap (or an alternate method of bank protection) many levee maintenance problems cannot be adequately addressed and remain a perpetual problem (adding to costs for landowners).

3) Work in managed wetlands includes grading, discing, installation of pumps, creation of waterfowl nesting islands, and the relocation, replacement, or installation of new duck blinds. Annual grading volumes are limited; therefore landowners may have to grade ponds on a rotational basis. This can add to the cost of equipment mobilization. Graded material may not be stockpiled, so in emergency cases (levee breach) material must be dredged from adjacent sloughs and special permission must be granted by the USACE to dredge (RGP 5). Delays in USACE approval allow damage to progress and therefore increase repair costs to the landowner.

   Discing acreage is not limited by RGP #3 but landowners observe a voluntary annual discing limit of 20% of their total ownership due to endangered species Salt Marsh Harvest Mouse (SMHM) concerns. This voluntary limit imposes the need for rotational discing that may slow the recovery of poorly managed wetlands and can add to the cost of equipment mobilization. Volume limitations generally do not hamper the creation of nesting islands. Limitations on blind work can slow progress on the development/improvement of a hunting program and can add to the cost of equipment mobilization.

Water control structure work is limited to replacement/maintenance of like structures (including bulkheads), installation of new drain structures/accompanying bulkheads, and maintenance of existing structures. 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).

A-2 U.S. FISH AND WILDLIFE SERVICE (USFWS) AND NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION FISHERIES (NOAA FISHERIES)

The USFWS and NOAA are charged with enforcement of the Federal Endangered Species Act (ESA). Through Section 7 of the ESA these agencies issue biological opinions of projects that may include conditions to protect species covered by the ESA.

In Suisun Marsh the USFWS and NOAA have mandated restrictions on the timing and location of maintenance activities and diversions through biological opinions issued on the RGP. Diversion restrictions are a condition of the biological opinion issued by NOAA for the protection of delta smelt and migrating salmon. Landowners diverting water for marsh management may use no more than 25% of their water control structures diversion capacity from 11/1 to the last day of waterfowl season and no more than 35% from 4/1 to 5/31. There is a total closure of water diversions in specified sloughs from 2/21 to 3/31.

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.

A-3 U.S. DEPARTMENT OF AGRICULTURE (USDA)

The USDA is a federal agency that provides a Pesticide Applicators Permit to SRCD and regulates herbicide use by landowners under this permit. The permit enables landowners to manage and manipulate vegetation with herbicides.

A-4 SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD (RWQCB)

The RWQCB is a local board of the State Water Resources Control Board that protects and enhances water quality. Under section 401 of the Clean Water Act, this agency must issue a Water Quality Certification for the activities covered by RGP #3. This certification says Marsh activities will not cause water discharges that violate State water quality standards. The RWQCB has also issued a Waiver of Waste Discharge Requirements under the RGP #3.

Landowners must also obtain concurrence from RWQCB prior to importing material into the Marsh. This process has been very long and time-consuming in the past making it more convenient for landowners to use pond substrate or dredge materials for maintenance and repair activities

A-5 CALIFORNIA DEPARTMENT OF FISH AND GAME (DFG)

DFG is a State agency that provides streambed alteration agreements through sections 1600 and 1601 of the DFG Code for projects and activities that would disturb river or stream habitats.

The DFG is also the State agency charged with enforcement of the California Endangered Species Act and the Native Plant Protection Act to protect and preserve threatened and endangered species. For managed wetland owners in Suisun Marsh this means that any work done in listed species habitat must be surveyed for listed species. For example, any work in tidal areas (pipe installation or bulkhead construction) requires a site inspection prior to starting work. If threatened or endangered plants are present, the DFG inspector will make recommendations to avoid or minimize impacts.

A-6 BAY AREA AIR QUALITY MANAGEMENT DISTRICT (BAAQMD)

The BAAQMD is a district of the State Air Resources Board that works with the local DFG and fire districts to provide marsh burn permits that specify the timing and acreage of a burn as well as other fire procedures. For managers, marshland burning may be the best tool for setting back vegetation succession, as it is inexpensive, quick, and efficient. In the past, fewer permits have been approved than are needed to use burning as an effective marsh management tool. Burning restrictions have retarded marsh management efforts in the Suisun Marsh.

A-7 SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION (BCDC)

BCDC is a State agency that developed, and currently upholds, the Suisun Marsh Protection Plan policies as outlined by the Suisun Marsh Preservation Act of 1977. BCDC has jurisdiction over the Primary Suisun Marsh as well as the Secondary Marsh that includes uplands adjacent to the Primary Marsh area. BCDC permits are issued for projects and maintenance activities in the Suisun Marsh.

The BCDC must approve individual landowner management plans, written as directed by the SMPA/SMPP, prior to their implementation. In addition to approval of landowner management plans, BCDC requires landowner to obtain permits for projects and other maintenance activities. The cost of these permits varies according to the type/size of the project. The BCDC restricts work subject to their authority from April 15 through October 1.

BCDC permitting issues generally do not hinder landowner marsh management. Permitting issues are mostly related to gas wells development and new building construction.

A-8 CALIFORNIA STATE LANDS COMMISSION (CSLC)

CSLC is a State agency that upholds the policies of the Suisun Marsh Protection Plan and other State resource policies when reviewing or preparing environmental documents for proposed projects. The State Lands Commission has the primary responsibility for carrying out the management recommendations in the SMPP on lands owned by the State and does not directly affect private lands.

A-9 SOLANO COUNTY DEPARTMENT OF ENVIRONMENTAL MANAGEMENT (DEM)

The DEM is a local agency that has policies similar to that of the Suisun Marsh Protection Plan, but also specifies land use details on a parcel scale. DEM regulations do not generally affect landowners in the Marsh.

A-10 SOLANO COUNTY MOSQUITO ABATEMENT DISTRICT (SCMAD)

The SCMAD is a local agency responsible for the control of mosquitoes in Suisun Marsh through the use of chemicals and encouraging beneficial water management. The SCMAD is not a permitting agency but more of a policing agency. They are responsible for detecting mosquito production sites and treating them to prevent mosquito-vectored diseases.

Costs to landowners for mosquito control (aerial spraying after fall flood) can be substantial. Some of the regulatory restrictions discussed above have hurt the landowner's ability to control mosquito production on their properties. For example, burning and discing salt grass is effective for mosquito control but these activities may be restricted by regulation. A fast flood followed by a fast drain may decrease mosquito production but activities that decrease flood time (adding flood structures, cleaning ditches, making new ditches, and building new interior levees) are restricted or prohibited.

Appendix B

Primary Water Control Structures Used on Managed Wetlands in Suisun Marsh

B-1 LEVEES (Exterior/Interior)

Exterior levees are embankments that prevent uncontrolled flooding of marshland due to tidal action. Exterior levees allow for management of water outside and inside the managed wetland. The crown of these levees is optimally about 9 feet above zero tide with a 15-foot top width. Exterior levees are used in conjunction with interior levees, ditches, and water control structures to control water on the land they surround.

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.

There is routine repair and maintenance required on exterior and interior levees. Typical levee maintenance work includes restoring levee contours, levee resurfacing, repair of gates and other hydraulic structures, mowing vegetation, discing levee soils, and embankment repair (Ramlit 1983). Typical causes of levee maintenance problems include storm events, wave action, levee subsidence, and rodent damage (DWR 2001). The minimum standards for the repair and maintenance of existing levees are as follows (SRCD 1980):

> For exterior levees, the levee contours shall be restored to match the previously existing levee cross section. If the existing side slope is eroded beyond 1.5 foot rise to a 1 foot run (1.5:1), the slope should be rebuilt to 2:1. Coring should be done only where required to repair damage from animal channels or eliminate seepage.
>
> For interior levees the levee contours shall be restored to match the previously existing levee cross-section. If the existing side slope is eroded beyond 1.5:1, the slope should be rebuilt to 2:1. Coring should be done only where required to repair animal channel damage or eliminate seepage.

B-2 DITCHES (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 B-1)

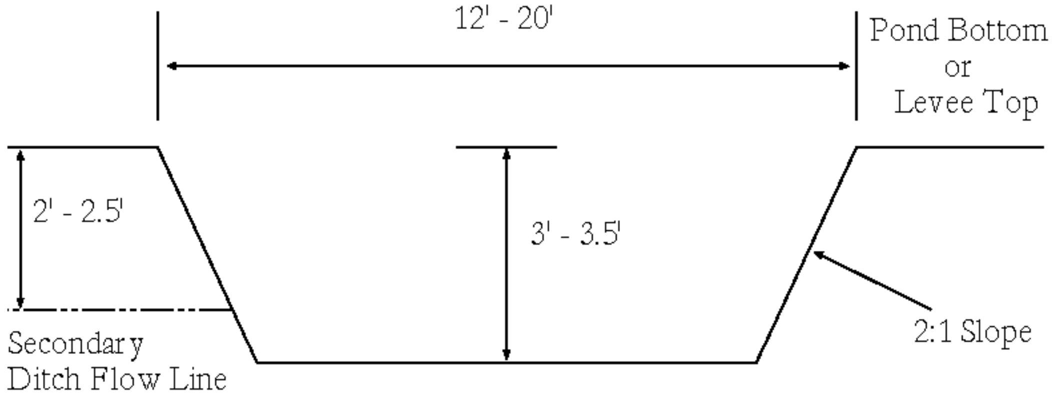


Figure B-1. Cross Section of Primary Ditch

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 B-2) These ditches connect “V” ditches to primary ditches and ultimately empty out to the water control structure (SRCD 1998).

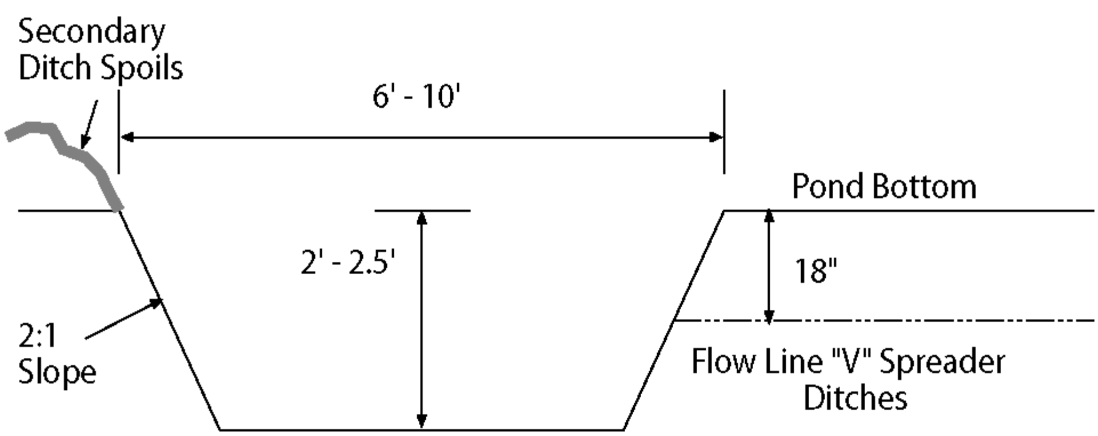


Figure B-2. Cross Section of Secondary Ditch

“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 B-3)

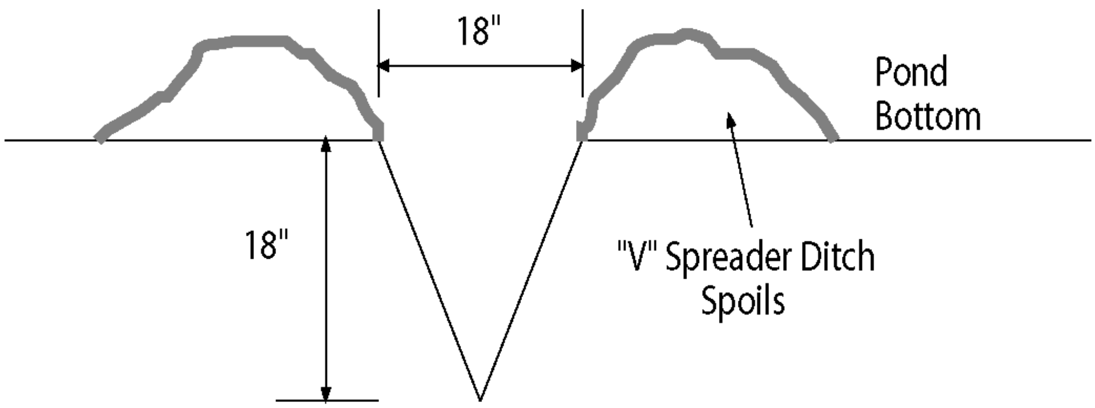


Figure B-3. Cross Section “V” Spreader Ditch

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).

B-3 WATER CONTROL STRUCTURES (Culverts/ Gates/ and Risers)

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, except risers and weir boxes, are constructed from stainless steel, plastic or asphalt coated galvanized, or alclad steel meeting the requirements of Interim Federal Specification WW-P-405 (SRCD 1980).

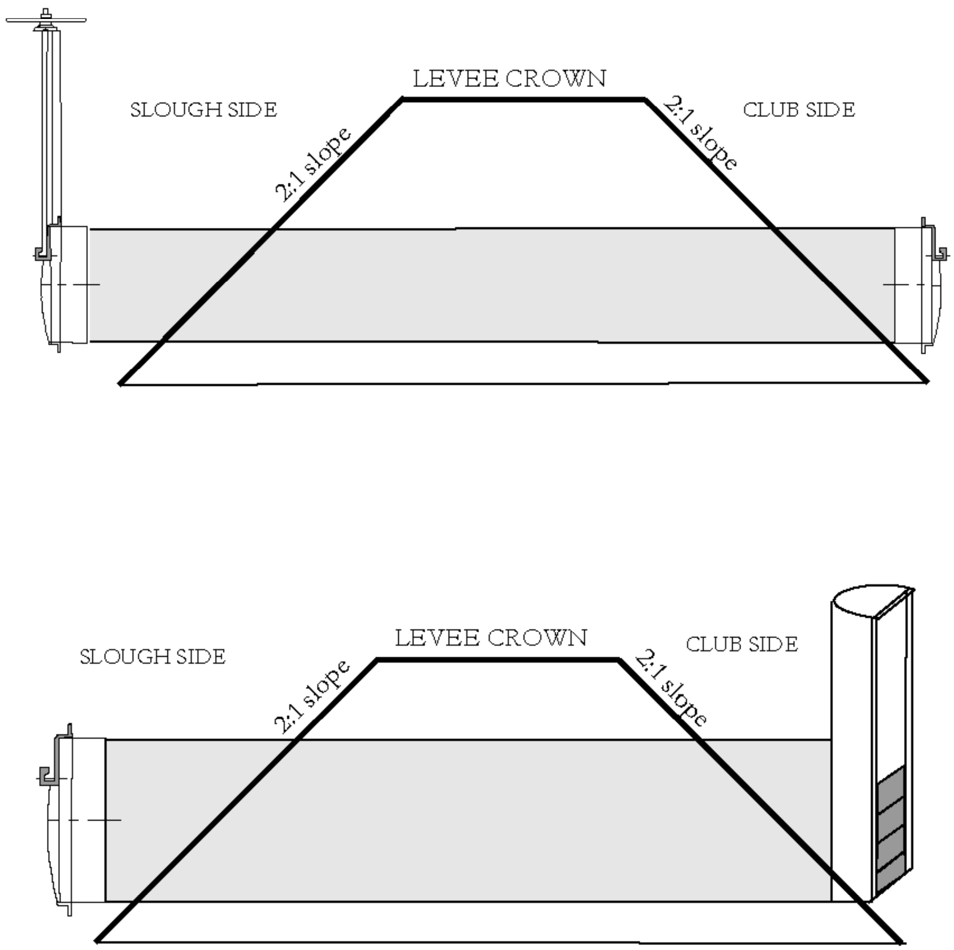


Figure B-4; B-5. Typical Exterior Levee Section For a Flood and Drain Gate

The six most commonly used water control structures used for flooding and drainage of ponds are culverts, flap gates, slide/flap gates, screw gates, flashboard risers, and flashboard boxes. These structures and their purposes as described by Rollins (1981) are discussed below.

Culverts are corrugated steel or plastic pipes placed in a levee for the purpose of conveying water from one side of the levee to the other (Rollins 1981). (Figures A-4 and 5) Exterior culverts should be 12 gauge steel or heavier whereas interior culverts should be 14 gauge steel or heavier (Rollins 1981).

Flap gates are hinged wooden or metal covers affixed to the end of culverts or redwood boxes. Flap gates are designed to allow the free flow of water in one direction and prevent back flow in the opposite direction. Water pressure against the flap controls the rate of flow through the gate. (Figure B-6)

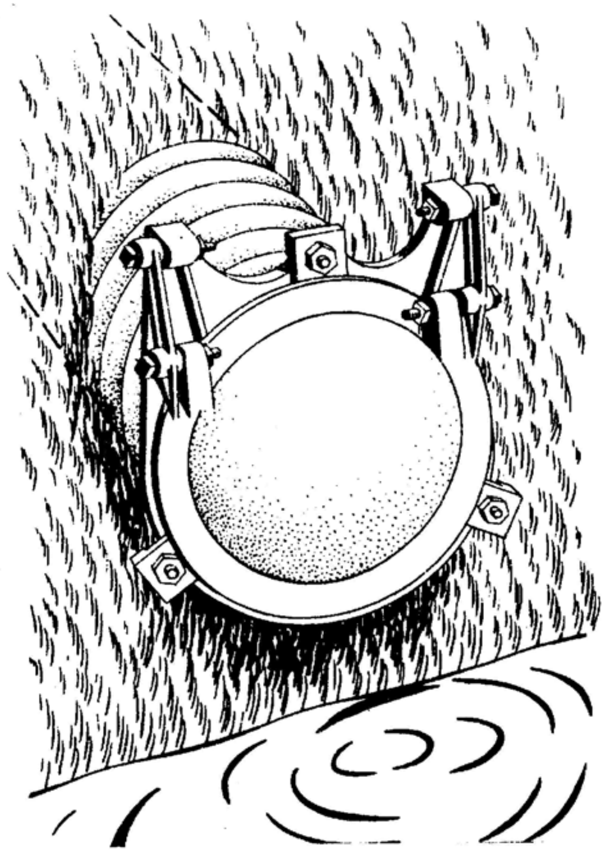


Figure B-6. Simple flap gate (Rollins 1981).

Slide/flap gates, also called screw/flap 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. Slide/flap gates are nearly always installed on the outboard side of levees and in combination with 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 B-7)

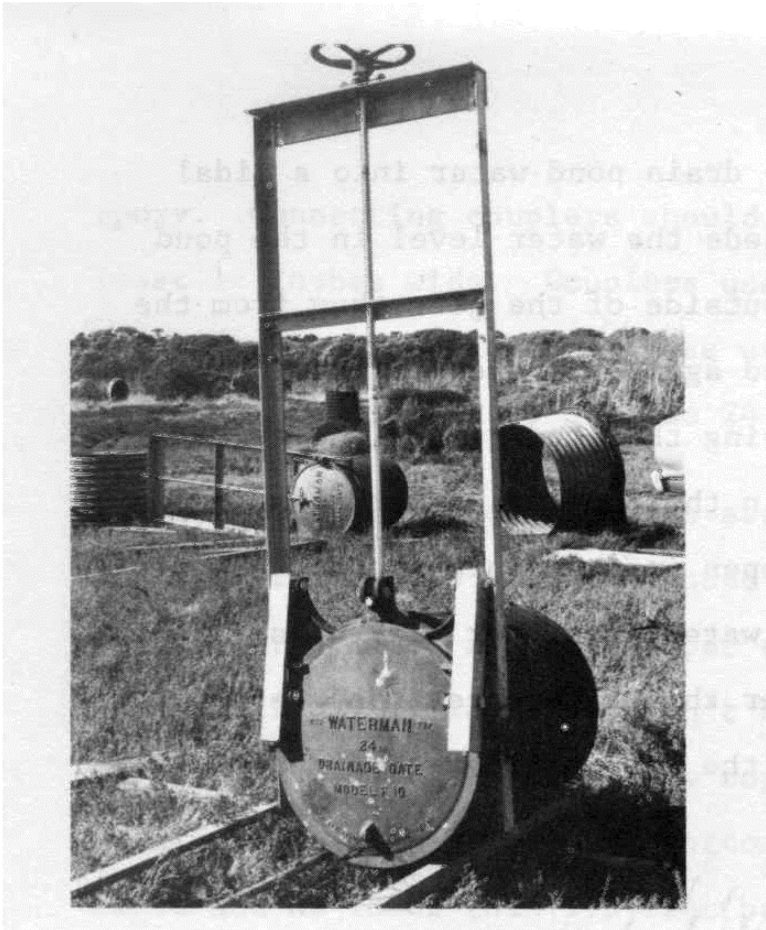
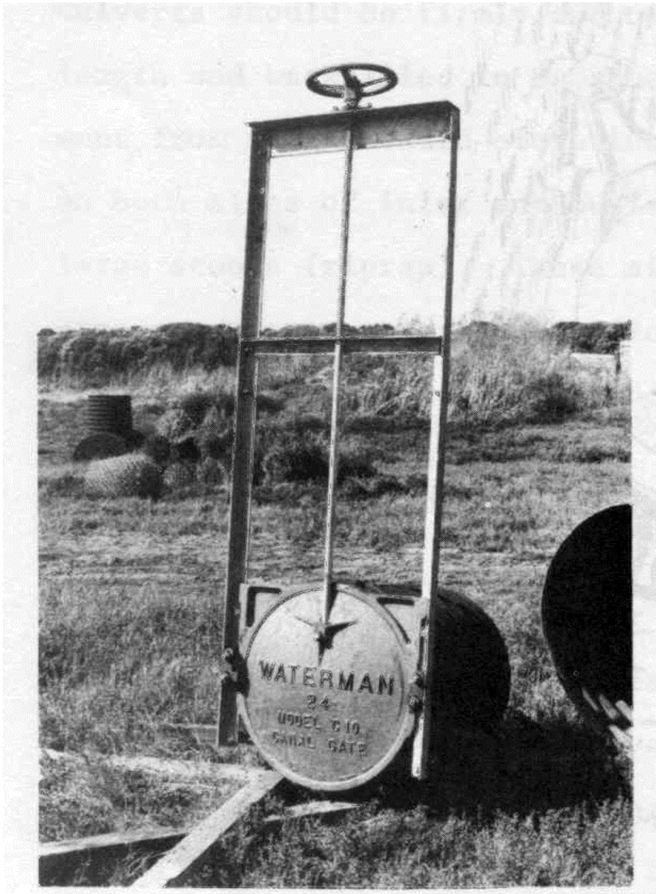


Figure B-7. Slide flap gate. Photo by D Dick (Rollins 1981).

Slide gates, also called 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 slide/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 B-8)



Slide gate. (photo by D. Dick)

Figure B-8. Slide gate. Photo by D. Dick (Rollins 1981).

Flashboard risers consist of a length of corrugated metal pipe cut in half longitudinally and placed vertically on top of the inboard end of an inlet or outlet culvert. The bisected culvert is fitted with grooved metal frames on each side. Wooden planks are inserted one on top of the other into the grooved frame, thus preventing water, except that which spills over the planks, 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 B-9)

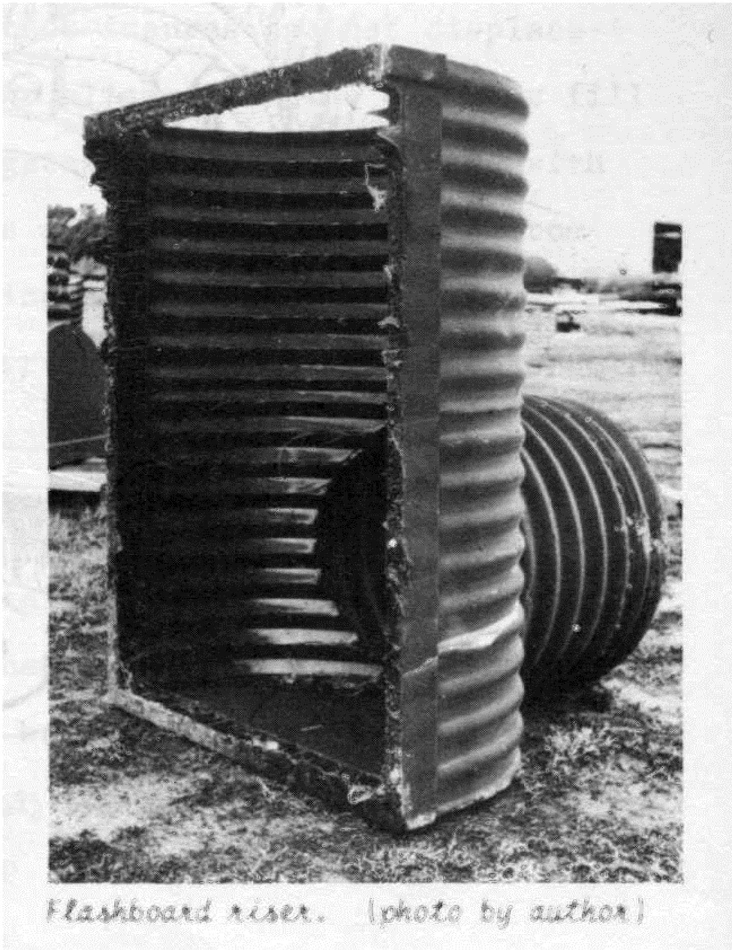


Figure B-9. Flashboard riser. Photo by G. Rollins (Rollins 1981).

Flashboard boxes or weir boxes are redwood boxes with side grooves for inserting wooden planks. The planks are placed one on top of the other to obtain the desired water height. They function in the same manner as flashboard risers, but on a smaller scale. Weir boxes are placed in interior levees to control the amount of water entering or draining from a pond or supply ditch.

All water control structures should be maintained in good working order, free of debris and silt. Leakage should be kept at the minimum practical and necessary repairs should be made promptly. Water passage capacities should be maintained at levels that will permit a 30 day flood and drain cycle to be achieved (SRCD 1980). Plastic water control structures have a possible life expectancy of 20-30 years where steel is expected to last 8 to 12 years on average (DWR 2001). The average cost of replacing a water control gate is $15,000 (DWR 2001).

B-4 CONTROLLABLE TOPOGRAPHY

Wetland managers can encourage desired plant species in part by contouring and disturbing pond bottoms. Grading pond bottoms can alter topography. The soil removed from pond bottoms can be used to create higher elevations in low pond areas or to create upland habitat such as resting islands. Changes in topography to create diverse pond bottom elevations can cause changes in plant communities. Desirable wetland plants readily invade disturbed soils from discing at the higher pond elevations such as dock, annual grasses, upland herbs, and brass buttons (Rollins 1981). Relatively level ponds with high elevations and good drainage produce quality stands of fat-hen (Rollins 1981). Alkali bulrush commonly occurs at lower pond elevations that are not level (Rollins 1981). Pickleweed, sea purslane, and lamb's quarter are other marsh plants commonly found at lower pond elevations (Rollins 1981). Other more influential factors affecting plant community composition directly related to pond topography are length of time and depth of submergence as well as soil salinity.

Resting islands are areas of exposed pond bottom and short or mowed vegetation that allow wildlife a clear field of view for predators (SRCD 1998). Resting islands are created by grading the pond bottom to between 1" below water level to 6" above water level. These islands provide refuge for terrestrial species such as the salt marsh harvest mouse, shallow areas for shorebirds, and resting areas for waterfowl. Islands also provide nesting habitat for both mammals and birds.

B-5 PUMPS (Permanent/Portable)

Permanent or portable water pumps provide managers with the opportunity for intensive water management through the proper timing of 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 dependant 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.

Permanent pumps are electrical, requiring costly electricity to run. The annual electrical costs for Grizzly Island Wildlife Area averages $37,000 (DFG 1988). These pumps are permanently enclosed in wooden pump houses suspended above a primary ditch on pilings adjacent to a water control structure. 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. Low pump efficiency may indicate that the impeller is worn and in need of replacement. 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 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.

B-6 FISH SCREENS (Conical/Flat screen)

Screened water diversions assist in the protection of aquatic species such as winter and spring run salmonids and delta smelt while allowing managers to effectively manage wetlands. Screened water diversions allow managers to maintain diverse managed wetland habitats because managers are able to access water during critical germination periods and periods of fresher water (SRCD 1998).

Both fish screen types, conical and flat screen, are used in the Suisun Marsh. Fish screens are self-cleaning to comply with regulated approach velocities and minimize maintenance costs. The design of fish screens allows manual rising of the screens for removal, repair, and out-of-water storage during non-diversion periods to minimize corrosion. Due to the brackish environment, fish screens are constructed out of a corrosive resistant material with some coated with epoxy and cathodically isolated to decrease corrosion.

B-7 STRUCTURE MAINTENANCE CONSTRAINTS

The major constraint posed by water control structures and their maintenance is cost. Water control structure maintenance and replacement can cost from hundreds to tens of thousands of dollars. Levees need to be periodically refurbished or cored, ditches need to be kept clear of obstructions such as debris and silt, and water control structures need to be kept in good working order. Pumps and fish screens also need periodic maintenance, cleaning, or replacement to insure efficient operation.

The other major constraint includes permitting requirements for maintenance and replacement of control structures through the Suisun Resource Conservation District's U.S. Army Corps of Engineers (USACE) Regional General Maintenance Permit (RGP) for the primary management area of the Suisun Marsh. Any work not covered under the existing permit, such as installing new flood structures, requires an individual permit from the USACE.

Appendix C

Regulatory Actions on Management of Seasonal Wetlands that are Subject and Exempt from a BCDC Permit

The BCDC requires a permit for:

1. The placement or erection of any solid material or structure on land, or in or under water;
2. The discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste;
3. Grading, removing, dredging, mining, or extraction of any materials;
4. Change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act;
5. Most other land divisions including lot splits.
6. Change in the intensity of use of water or in access thereto;
7. Construction, reconstruction, demolition, or alteration of the size of any structure; and
8. The removal or harvesting of major vegetation other than for agricultural purposes.

The BCDC excludes the following from needing a permit:

1. A change in the intensity of use of water;
2. The removal or harvesting of major vegetation where such change, removal or harvesting is to maintain or improve wildfowl habitat and does not have a significant, adverse effect on other fish and wildlife resources in the marsh;
3. Improvements to existing single family residences;
4. Repair, replacement, reconstruction, or maintenance that does not result in an addition to, or enlargement or expansion of, the object of such repair, replacement, reconstruction, or maintenance; and
5. Any development specified in the component of the Suisun Resource Conservation District's local protection program, including a duck club's individual management plans.

Appendix D

Initial Draft

Conceptual Model for Managed Wetlands in Suisun Marsh

Compiled by Department of Fish and Game (DFG) and Suisun Resource Conservation District (SRCD) staff

Contributors:

Laureen Barthman – Thompson (DFG)
Kristin Bruce (SRCD)
Sarah Estrella (DFG)
Paul Garrison III (DFG)
Craig Haffner (SRCD)
Julie Niceswanger (DFG)
Gina Van Klompenburg (DFG)
Bruce Wickland (SRCD)

With input from:

Dennis Becker
Laurie Briden
Cecilia Brown
Steve Chappell
Steve Culberson
Cassandra Enos
Chris Enright
Bellory Fong
Terri Gaines
Jasper Lament
Conrad Jones
Victor Pacheco

Facilitated by:
Zachary Hymanson
Stuart Siegel

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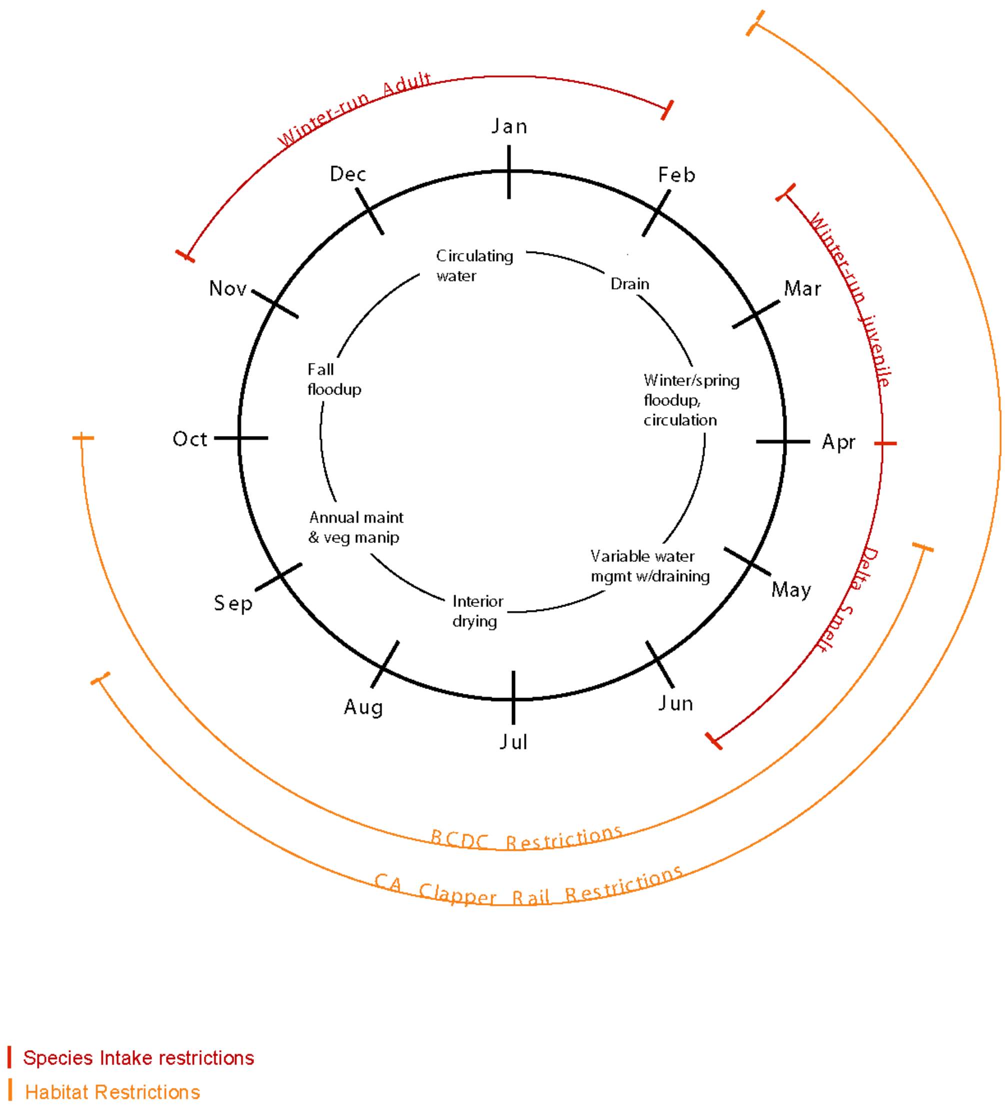


Conceptual Model for Managed Wetlands in Suisun Marsh

The goal of this model is to describe existing conditions and operations on managed wetlands in the Suisun Marsh (Marsh). For the purposes of this model, managed wetlands are diked wetland areas managed specifically for waterfowl food production. Management and conditions on upland areas managed for the benefit of waterfowl have also been included.

The intention is for the model to remain in draft form since existing conditions will change continually. New uncertainties and data gaps will be identified while other uncertainties are clarified and data gaps are filled. Those discoveries will be incorporated into the model as the new existing state of knowledge. This model will serve as the starting point for future actions on managed wetlands in the Suisun Marsh. This and subsequent versions of the model will provide a timeline of understanding and progress through the implementation process.

1.0 MANAGED WETLAND MANAGEMENT GOALS AND ASSUMPTIONS

<u>Goals</u>

- Attract waterfowl desirable to hunters to the Suisun Marsh
- Provide wintering waterfowl food and habitat
- Provide breeding habitat for resident waterfowl and ground nesting birds
- Preserve open space while maintaining hunting opportunities and experiences

<u>Assumptions</u>

- Managing wetlands to maximize waterfowl food plant quantity and diversity will maximize wintering waterfowl numbers in Suisun.
- The ability to manage water is the key to achieving managed wetland goals.

2.0 CURRENT CONDITIONS

This section describes the existing physical and biological conditions in the Marsh affecting wetland management strategies. Physical and biological conditions drive management, which in turn determines the resulting habitat, and ultimately the species that will utilize that habitat (Figure 1).

Figure 1. Simple model of driving forces in a managed wetland system.

2.1 PHYSICAL

This section outlines the physical conditions that primarily affect managed wetlands existing in the Marsh today. As this section is common to all the models and the environmental documentation, efforts were not duplicated here. Instead, information was included which may directly influence the management of wetlands in the Marsh.

The salinity and/or water quality models may give a better description of the mechanisms underlying the observations and findings presented in this section.

2.1.1 Applied water salinity

Rollins (1973) investigated the affects of applied water salinity on soil water salinity. Rollins 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. In addition to Rollins' work, the Suisun Ecological Workgroup (SEW) also found a strong correlation between the applied water salinity and pond water salinity (DWR 2001).

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 Managed Wetland Conceptual Model Diagram), 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 United States Department of Agriculture (USDA) (1977) stated that appropriate circulation of pond water and leaching of soil salts prevents increases in soil water salinity above natural levels for Suisun 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, evaporating, and concentrating those salts (DWR 2001). Overall, pond water salinity values tend to be 5-10 mS/cm greater than that of the applied water.

2.1.2 Slough water salinity / Marsh-wide salinity gradient (DWR 2001)

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 Suisun Marsh include, but are not limited to tides, climate, delta outflow, Suisun Marsh Salinity Control Gate (SMSCG) operations, creek inflows, managed wetland operations (as allowed under current regulatory restrictions), urban runoff, and Fairfield-Suisun Treatment Plant effluent flows. 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.

During times of high Delta outflow, the Suisun 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 Suisun Marsh Salinity Control Gates 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. Several creeks originate in the area bordering the Suisun Marsh including Green Valley, Suisun, Dan Wilson, Ledgewood, McCoy, Union, and Denverton. The influence of creek inflows on salinity levels is most significant in the northwestern Marsh, where the sloughs are smaller and influences of Delta outflow and Suisun Marsh Salinity Control Gates operation are less pronounced. Union, Suisun and Green Valley creeks are perennial creeks with minimal base flows that respond quickly to precipitation and runoff. The other creeks are ephemeral and usually flow only during times of significant rainfall (DWR 1995).

2.1.3 Soils

Soils and soil management are important elements in creating a successful managed wetland.

2.1.3.1 *Soil types*

Suisun 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 1977). The soil types generally occur in the following order extending outward from the sloughs: Reyes, Tamba, Joice, and Suisun. The Department of Water Resources (DWR) (2001) evaluated the relationship between soil type and soil water salinity. No consistent patterns of soil water salinity were seen based on soil type and DWR (2001) concluded that other factors such as site location, site elevation, and water management had more significant impacts on soil water salinity than soil type.

2.1.3.2 *Soil salinity*

Suisun Marsh soils that were historically inundated by the brackish tides are saline soils (DWR 2001). Soil is always moist in 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). Large areas of managed wetlands in the Marsh have soils isolated from daily tidal inundation resulting in more saline soils (DPW 1931). 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 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).

Rollins (1973) investigated the effects of applied water salinity on soil water salinity. Rollins' concluded that there was a significant relationship between applied water salinity and the soil water salinity. He also found that leaching with low salinity water reduced soil water salinity. Increases in soil salinity at most monitored sites (monitoring program 1984 to 1995) can be contributed to low Delta outflow, diversion restrictions, and below normal precipitation during the drought years of the monitoring period (DWR 2001). A time lag is apparent between applied water salinity and soil water salinity. Based on the monitoring program data, a direct relationship may be present between the applied water in the fall (October-November) and soil water salinity for the entire year (DWR 2001). In permanently flooded ponds, water must be circulated to remove high salinity water left by evaporation to keep the ponds from acting as salt collection ponds (USDA 1975).

DWR (2001) studied the influence of pond water level on soil water salinity. Their analysis found an immediate decrease in soil water salinity as ponds were flooded in the fall when water was initially applied to dry soil. The draining of ponds after the water management season resulted in a decrease of soil water salinity as the water level dropped with an increase in soil water salinity after drainage was complete. Pond and soil water salinity appeared to be independent of flood duration (DWR 2001).

DWR's (2001) analysis of spatial trends in soil water salinity found that water management (timing and duration of water application, circulation, and leaching) might play a greater role in determining soil water salinity than the Marsh-wide salinity gradient. For example, western Marsh sites with poor water management generally had the highest soil water salinity of all monitored sites. However, western Marsh sites with preferred water management had lower soil water salinity than some eastern Marsh sites, regardless of the overall salinity gradient.

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 plant diversity.

2.1.4 Water year

The State Water Resources Control Board (SWRCB) has five water year classifications that include: wet, above normal, below normal, dry, and critical. (SWRCB 1978). Water years with more rainfall result in less saline water. The salinity of the slough water, applied water, and pond water show similar trends in salinity during different water years. However, there is often a lag in pond water salinity response to changes in channel water salinity from months to a year (DWR 2001). Pond water salinity follows the same annual trend as applied water salinity with the pond water salinity being 2-10 mS/cm higher than applied water salinity (DWR 2001).

2.1.5 Subsidence

Although little research has been done on the rate and causes of subsidence in Suisun Marsh, the subsidence of similar peat lands of the Sacramento-San Joaquin Delta has been investigated for decades. Six factors contributing to the subsidence of peat soils are geological subsidence of the entire area, compaction by tillage machinery, shrinkage due to drying, oxidation, burning, and wind erosion (Weir 1980). Of these factors shrinkage, oxidation, and burning may have the most influence on the subsidence rate of peat soils.

Shrinkage occurs when highly organic soils dry; thoroughly dry soils do not recover their original volume upon rewetting (Weir 1980). Oxidation is greatly increased by reclamation, drainage, and cultivation of peat soils that exacerbates subsidence rates (Weir 1980). Burning off the upper few inches of topsoil was a common practice in the Delta (Weir 1980). It was done to clean up the fields by destroying weeds and weed seeds. Limited burning is conducted in the Suisun Marsh for similar reasons on privately managed duck clubs.

2.2 STRUCTURAL COMPONENTS OF WATER CONTROL FACILITIES

Marsh management and the water control facilities that manipulate the timing, duration, and depth of flooding play a significant role in determining Suisun Marsh 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. Financial constraints also determine the level of upkeep and maintenance of those structures. Appendix A is an outline of the primary water control structures used and their function on managed wetlands in Suisun Marsh. Figure 2 depicts how the individual components of a managed wetland work together to move water.

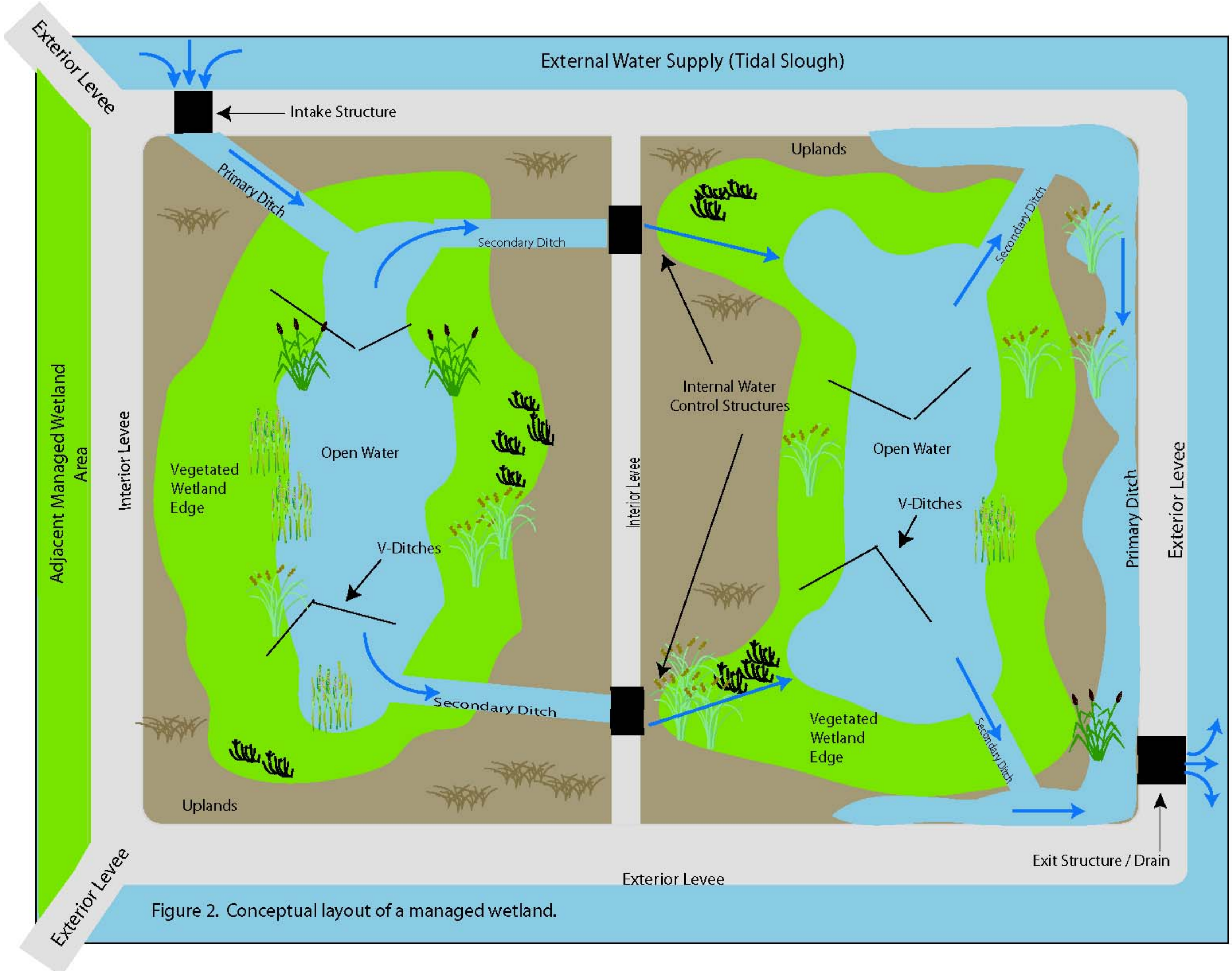


Figure 2. Conceptual layout of a managed wetland.

2.3 EXISTING BIOLOGICAL

2.3.1 Vegetation

2.3.1.1 *Historical and current conditions*

Historically, Suisun Marsh was comprised of a wide plain of saltgrass (*Distichlis spicata*) associations supporting a large number of brackish (halophytic) marsh plant species. Dramatic climate cycles produced plants in highly variable abundances (DWR 2001). Historic brackish marsh habitat is characterized by high plant diversity and widely variable water salinities. Germination of most halophytes often occurs when high salinity water is followed by fresh water (such as rain). It is believed that water of such salinities preconditions the embryo for germination and has an osmotic shock effect that weakens the seed coat and stimulates subsequent germination in fresh water. The seeds of halophytes have developed a number of adaptations that allow them to avoid salt stress and to time germination for successful establishment and reproduction of plants (DWR 2001).

Today, ninety percent of the wetlands in Suisun are diked and managed as food, cover, and nesting habitat for wildlife (SRCD 1998). Because diked areas in Suisun are cut off from tidal influences, they lack the gradual ecotonal gradations of tidal areas, limiting plant diversity. There are sharper transitions between low marshes and uplands, if there are any at all (DWR 2001). The upper zones of levees are typically weedy in nature and support a variety of introduced and invasive species (Goals Project 2000).

In the Suisun Marsh, pickleweed (*Salicornia virginica*) and annual grasses are the dominant plants in diked wetland acreage, followed by cattails (*Typha* spp.), saltgrass (often in pure stands), alkali bulrush (*Scirpus maritimus*), and various weeds. By contrast, the dominant plants in tidal acreage include: tules (*Scirpus acutus*); three-corner bulrush (*Scirpus americanus*); cattails; and saltgrass associations with other plants, such as pickleweed, arrowgrass (*Triglochin maritima*), Baltic rush (*Juncus balticus*), and sea milkwort (*Glaux maritima*) (DFG 2000).

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. When lands are cut off from all tidal influence, they are susceptible to invasions by nonnative invasive species (DWR 2001).

2.3.1.2 *Management objectives*

In diked lands of Suisun Marsh, suitable vegetation is a key component to the survival of waterfowl, pheasants, small mammals (including the endangered salt marsh harvest mouse (*Reithrodontomys raviventris haliocoetes*)), and tule elk (*Cervus elaphus nannodes*). Most management in these areas favors 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). 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 (See Appendix B for plant requirements and habitat value). Elsewhere in the San Francisco Bay region, many of the same plants grow abundantly in tidal areas subject to higher salinities than those found in Suisun (DWR 2001). In some cases, marsh management favors less salt-tolerant plants, such as watergrass (*Echinochloa crus-galli*) and smartweed (*Polygonum* spp.).

Traditionally waterfowl managers have focused on certain plants considered to be food for ducks and geese, including fat hen (*Atriplex triangularis*), brass buttons (*Cotula coronopifolia*), alkali bulrush, and to a lesser extent pickleweed (DWR 2001 and Rollins 1981). Ed Burns (University of California, Davis) released a report in 2003 on food habits of green-winged teal (*Anas crecca*), pintail (*Anas acuta*), and mallards (*Anas platyrhynchos*) in managed marshes of Suisun. An earlier food habit study used gizzard samples to determine preference, which biased results in favor of harder, more slowly digested seeds, such as alkali bulrush. Another earlier study related the percentage composition of plant foods to the percentage of ground coverage in feeding areas. Burns analyzed fresh esophageal contents of actively feeding ducks and ducks returning to the roost (pass-shot) in the early morning. His findings concluded that not only were there widely different preferences among the three species, but the top three most eaten plants were alkali bulrush, sea purslane (*Sesuvium verrucosum*), and watergrass, followed closely by fat hen.

Pickleweed is also an important food plant, not only for the food value of the leaves, but also for the high numbers of invertebrates found among the leaves (De Szalay and Resh 1996). Invertebrates, also important in the diet of waterfowl, require clean oxygenated (circulated) water (Rollins 1981). Other Suisun Marsh plants important in the diets of waterfowl include lamb's quarters (*Chenopodium album*), wigeongrass (*Ruppia maritima*), swamp timothy (*Crypsis schoenoides*), smartweed, and rabbitsfoot grass (DWR 2001, Burns 2003).

In permanently flooded ponds, emergent vegetation typically occupies 30-70% of the pond area (SRCD 1998). In shallow parts of these ponds, cattails, tules, sago pondweed (*Potamogeton pectinatus*), and wigeongrass provide birds with shelter from wind, low temperatures and predators (DWR 2001). Ducklings are particularly attracted to these areas due to high concentrations of invertebrates.

Upland vegetation includes habitat for ground-nesting birds including waterfowl, short-eared owls (*Asio flammeus*), northern harriers (*Circus cyaneus*), and ring-necked pheasants (*Phasianus colchicus*). Waterfowl species known to nest in Suisun include mallards, pintail, gadwall, cinnamon teal (*Anas cyanoptera*), northern shovelers (*Anas clypeata*), wood ducks (*Aix sponsa*), ruddy ducks, and Canada geese (DWR 2001). Ducks nest sites can occur up to one mile from water. Ideally, these areas should include tall grasses, such as rye (*Lolium* spp.) and brome (*Bromus* spp.), mixed with other plants, such as vetch (*Vicia* spp.) and fat hen, which remain green throughout summer (SRCD 1998). Rollins (1981) suggests that no more than 25% of a duck club should be planted with grains. Geese prefer nesting over water in cattails and tules, ideally with an open water to vegetation ratio of 9:1 (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 15th. See the section "Water Management Schedules" (page 27) for more information on water management schedules.

2.3.1.3 *Problems affecting managed marsh vegetation*

<u>Invasives and Nonnative Species</u>

Diked marshes are at a greater risk of invasion by nonnative weeds because of a higher level of disturbance, such as burning and discing; and past land use, such as grazing, farming or addition of fill (Goals Project 2000). Disturbance factors and levels of disturbance vary widely and can produce extreme variations in habitat. Levees are continually disturbed by maintenance or traffic, leaving them bare or vegetated by invasive weeds. Weeds such as perennial pepperweed, which invades first along dredge spoil before spreading to wetlands, can use this disturbance as an opportunity to invade an area (Baye 2000). Coyote brush (*Baccharis pilularis*) often becomes dense on infrequently maintained levees (Goals Project 2000).

Diked marshes are also more susceptible to invasion by nonnative plants because of decreased salinity variability. This lack of variability is also the mechanism through which land managers encourage particular plants or groups of plants, both native and nonnative, rather than maintain a high diversity of native species. Some nonnative plants are valuable food sources for waterfowl while others have little or no value and can be difficult to eradicate.

Subsidence

Over time, diked marshes may subside far below N.G.V.D. (National Geodetic Vertical Datum or mean sea level) and may be close to groundwater level. This results in the accumulation of salts and an inability to drain by gravity alone (Goals Project 2000). Slow drainage may lead to ponding after heavy rainfall. High soil acidity and free iron (caused by prolonged inundation followed by drainage) may promote only a few species, such as pickleweed and saltgrass. In extreme conditions, the affected ground may remain bare (Goals Project 2000).

2.3.2 Fish and Wildlife

This section encompasses a number of different species found in the Suisun Marsh. As previously stated, one of the goals of management on diked wetlands is to provide habitat for migratory and resident waterfowl. A variety of other wildlife also benefit from the management of wetlands in Suisun. While some species benefit from habitat created by marsh management, other species may be negatively impacted by management actions or resulting habitat manipulation. Species that may be impacted positively or negatively by wetland management were included in this section. Tables 1 and 2 give a brief overview of species and impacts by or to managed wetlands. Detailed text discussing information contained in Tables 1 and 2 can be found in Appendix C.

Life history information for the species included in this section can be found in the individual species models. Additional information regarding species regulatory restrictions is discussed in Appendix D.

Table 1. The following table is a summary of the species that may use managed wetlands, or be impacted positively or negatively by wetland management practices. Most information was taken from existing studies or text. However, some species information is based on field observation.

Table 1.1 Harvested Species

Species	Use of Managed Wetlands	Impact	Included Species/Distribution	Comments
Migratory waterfowl	Wintering: cover, foraging.	+	Swans, Geese, Whistling ducks, Dabbling ducks, Diving ducks, Sea ducks, stiff-tailed ducks. (See text in Appendix C for a complete list of species.) Found throughout the Marsh.	Suisun usually provides the first available water to migratory waterfowl in the region. Waterfowl may move in and out of the Marsh throughout the winter. Numbers may fluctuate significantly from year to year depending on rainfall, water availability, and other factors.
Resident waterfowl	Resident: cover, foraging, nesting.	+	Dabbling ducks: mallard, pintail, cinnamon teal, Northern shoveler, gadwall, and wood ducks. Divers: scaup, scoters. Found throughout the Marsh.	Nesting success high in Suisun (McLandress 1996).
Ring-necked pheasant	Resident: cover, foraging, nesting.	+	Found throughout the Marsh.	Ample nesting opportunities in managed upland and seasonal wetland habitats.
Tule elk	Resident: cover, foraging, breeding.	+	Restricted to Grizzly Island proper.	Increasing in numbers. Provide hunting opportunities.
Pigs	Resident: cover, foraging, breeding.	+	Primarily found on Joice Island and Rush Ranch.	Increasing in numbers.

+ Positively impacted by managed wetland management
- Negatively impacted by managed wetland management
* Impact by managed wetland management uncertain

Table 1.2 Other Species of Importance

Species	Use of Managed Wetlands	Impact	Included Species/Distribution	Comments
Egrets and Herons	Resident: cover, foraging, nesting.	+	Great egret, black-crowned night heron, cattle egret, snowy egret, great blue heron. Found throughout the Marsh.	Rookeries found in trees used for wind blocks; birds forage in ponds and water delivery ditches. *Uncertainty: Fish screens may impact this species foraging habitat.
Other water birds	Resident: cover, foraging, nesting.	+	Virginia rail, pelicans, cormorants, grebes, moorhens, bitterns, and coots. Found throughout the Marsh.	Managed wetlands provide foraging and some nesting habitat. *Uncertainty: Management practices that manipulate vegetation may impact nesting birds.
Raptors – common to Suisun	Resident: cover, foraging, nesting.	+	Turkey vulture, white-tailed kite, golden eagle sharp-shinned hawk, cooper's hawk, red-shouldered hawk, red-tailed hawk, merlin, American kestrel. Found throughout the Marsh.	Managed wetlands provide foraging and some nesting habitat in upland areas. Northern Harrier separately listed in Table 1.4.
Owls	Resident: cover, foraging, nesting.	+	Great horned owl, barn owl, screech owl, short-eared owl. Found throughout the Marsh.	Wetlands provide foraging and nesting habitat.
Shorebirds	Resident and seasonally: cover, foraging, nesting.	+	Avocets, curlews, dowitchers, phalaropes, sandpipers, stilts, and yellowlegs. Found throughout the Marsh.	Management practices that manipulate vegetation may impact ground nesting birds in wetland areas. 500 acres are specifically managed for shorebirds on Grizzly Island.
Passerines	Resident and migratory: cover, foraging, nesting.	+ & *	Found throughout the Marsh.	Wetlands provide foraging and nesting habitat. *Uncertainty: Management practices that manipulate vegetation may impact nesting birds in wetland areas.
Bats	Resident, migratory, and transient: limited roosting, foraging.	*	Big brown bat, red bat, hoary bat, Myotis species, Western pipistrelle, greater mastiff bat, Mexican free-tailed bat. Expected to be found throughout the Marsh.	Limited roosting in bridges, windbreaks, and buildings. Little information regarding actual presence in Suisun. *Uncertainty: Unknown how important bats are for mosquito control, and how management and mosquito control effect bats.

+ Positively impacted by managed wetland management
- Negatively impacted by managed wetland management
* Impact by managed wetland management uncertain

Table 1.3 Managed Wetland Listed Species - Listing codes are found at the end of Table 2.

Species	Use of Managed Wetlands	Impact	Listing	Comments
Salt-marsh harvest mouse	Resident: cover, foraging, nesting.	+ & -	FE, SE, FP	Managed wetlands could impact the species both positively and negatively. SMHM is widely distributed in Suisun in both managed and tidal areas. SMHM may be impacted by flooding if no refugia available; managed wetlands voluntarily limit disking to 20% of landowner acreage to protect the SMHM.
Pallid bat Townsend's big-eared bat Myotis species	Resident, migrant, and transient: foraging, roosting.	*	CSC FSC, CSC FSC, CSC	*Uncertainties: Unclear how management and mosquito control may affect bats. It is also unknown how and when bats use Suisun.
Suisun shrew	Resident: cover, foraging, breeding.	*	FSC, CSC	Presumed to use upland edge or areas adjacent to levees. Several unidentified shrews have been captured in Suisun. *Uncertainty: Overall distribution and impacts by wetland management practices are unknown.
American bittern	Resident: cover, foraging, nesting.	+ & *	FSC	Dense cattails and bulrush marshes are used for foraging and nesting; shallowly flooded areas and herbaceous uplands may also be used as foraging. * Uncertainties: Management practices that affect dense cattail and tule growth may affect nesting and foraging. Amount of use of managed wetlands unknown.
Golden eagle	Resident: foraging.	+	CSC, FP	Suisun provides open foraging areas for eagles nesting in Mount Diablo area and coastal ranges.
Ferruginous hawk	Migrant: winter cover, forage.	+	FSC, CSC	Suisun provides winter foraging areas.
Northern harrier	Resident: cover, foraging, nesting.	+	CSC	Nest in managed wetlands and upland fields. Nesting adjacent to waterfowl nests may improve waterfowl nesting success (Ackerman 2002). *Uncertainty: Management practices that manipulate wetland vegetation may impact nesting birds.
White-tailed kite	Resident: cover, foraging, nesting.	+	FSC, FP	Suisun provides wide open foraging areas; some limited roost sites.
American peregrine falcon	Resident and migrant: foraging, nesting.	+	SE, FP	Suisun provides wide open foraging areas; some limited roost sites.

+ Positively impacted by managed wetland management
- Negatively impacted by managed wetland management
* Impact by managed wetland management uncertain.

Table 1.3 (continued) Managed Wetland Listed Species

Species	Use of Managed Wetlands	Impact	Listing	Comments
California black rail	Unknown.	*	FSC, ST, FP	Found adjacent to, or within, thick vegetation of managed wetlands. Extent of use of managed wetlands unknown.
California clapper rail	None known.	*	FE, SE, FP	Have not been found on managed wetlands; possible impacts to the species from levee work have led to a restriction to maintenance activities during CCR breeding season. Impacts with compliance to current regulations unknown. Occurrence in the Marsh is variable yearly, seasonally, and temporally.
Long-billed curlew	Migrant: foraging, resting.	+ & *	FSC, CSC	Forages in wetlands and upland grasses. *Uncertainty: changes to upland vegetation and management may affect food resources.
Short-eared owl	Resident and migrant: cover, foraging, nesting.	+	CSC	Nest and forage in waterfowl management areas. Nesting adjacent to waterfowl nests may improve waterfowl nesting success (Ackerman 2002).
Burrowing owl	Resident: burrows, foraging, nesting.	0	FSC, CSC	Sparsely distributed in Suisun on upland areas. Usually burrows are outside of management areas. Species is not expected to be impacted by wetland management.
Loggerhead shrike	Resident and migrant: cover, foraging, nesting.	*	FSC, CSC	Observed foraging on managed wetlands. *Uncertainty: no formal studies or data available on use of managed wetlands.
Salt-marsh common yellowthroat	Resident: cover, foraging, nesting.	*	FSC, CSC	Common yellowthroats have been captured at Joice Island and near Benicia. Yellowthroats are commonly seen in tall emergent vegetation within diked managed and tidal wetlands of Suisun. *Uncertainty: The use of managed wetlands by the listed subspecies is uncertain.
Suisun song sparrow	Resident: cover, foraging, nesting.	*	FSC, CSC	Current ongoing studies at Rush Ranch. Song sparrows are seen throughout the Marsh. *Uncertainty: The use of managed wetlands by the listed subspecies is uncertain.
Western pond turtle	Resident: cover, foraging, nesting.	+	CSC	Found throughout Suisun waterways and adjacent areas. Managed wetlands provide basking and foraging. *Uncertainty: Use of managed wetlands not clear due to lack of studies.

+ Positively impacted by managed wetland management
- Negatively impacted by managed wetland management
* Impact by managed wetland management uncertain
0 No impact by managed wetland management

Table 1.3 (continued) **Managed Wetland Listed Species**

*Uncertainties related to fish species: Impacts to fish populations by low dissolved oxygen events in sloughs. Impacts to fish species by unscreened diversions with current regulations on intakes.
Please see related text for occurrence data.

Species	Use of Managed Wetlands	Impact	Listing	Comments
Pacific lamprey	Migratory, transient.	*	FSC	Lamprey infrequently detected in Suisun (Matern et all. 1997). Suisun is not identified as a spawning area for this fish (Wang 1986; Matern et all 1997).
Green sturgeon	Migratory, transient.	*	CSC	Rarely captured in Suisun. Suisun may provide some habitat, but does not provide spawning habitat (Moyle 1995). Suisun may be used as a migratory path.
Chinook salmon	Migratory, transient.	*	Central Valley fall-run: CSC Spring-run: FT, ST Winter-run: SE,FE	Regulatory restrictions for management. Diversion closures are imposed for all unscreened diversions during species presence in Suisun.
Central Valley steelhead	Migratory, transient.	*	FT	Regulatory restrictions for management. Diversion closures are imposed for all unscreened diversions during species presence in Suisun.
Delta smelt	Seasonal resident of larger sloughs.	*	ST, FT	Regulatory restrictions for management. Diversion closures are imposed for all unscreened diversions during species presence in Suisun.
Longfin smelt	Seasonal resident.	*	CSC	Principal nursery habitat for the species is Suisun and San Pablo bays. Regulatory restrictions for management. Diversion closures are imposed for all unscreened diversions during species presence in Suisun.
Splittail	Year round inhabitant.	*	FSC, CSC	Regulatory restrictions for management. Diversion closures are imposed for all unscreened diversions during species presence in Suisun.

+ Positively impacted by managed wetland management
- Negatively impacted by managed wetland management
* Impact by managed wetland management uncertain

Table 2. The following table is a summary of the species that may negatively impact managed wetlands or managed wetlands practices. Most information was taken from existing studies or text. However, some species information is based on field observation.

Table 2.0 Species of Management Concern

Species	Use of Managed Wetlands	Impact	Location	Comments
Mosquitoes	Seasonal: reproduction.	–	Found throughout the Marsh.	Public health risk, increased cost of management.
Red Fox	Not known to be in Suisun.	–	There is one unconfirmed sighting on Rush Ranch; species widely believed not to be in Suisun, but remains a concern.	Non-native predator of ground nesting birds. Future immigration to Suisun possible.
Muskrat	Resident: burrowing, foraging.	–	Found throughout Suisun water ways and adjacent areas.	Impacts to levees, and increased management costs.
Beaver	Resident: cover, foraging, breeding.	–	Found throughout Suisun water ways and adjacent areas.	Increased cost of management from impacts to water delivery systems; damming culverts and waterways. Population increasing.
Rats	Resident: cover, foraging, breeding.	–	Trapped in several areas of Suisun.	Pest, predator of nesting birds.
Pigs	Resident: cover, foraging, breeding.	*	Primarily found on Joice Island and Rush Ranch.	Instances of habitat destruction have been observed on managed wetlands. Provide limited hunting opportunities. *Uncertainty: Impact to managed wetlands in Suisun unclear.

+ Positively **impacts managed wetland** management
- Negatively **impacts managed wetland** management
* Impact **to managed wetland** management uncertain

California Endangered Species Act (CESA) Listing Codes: The listing status of each species is current as of January 2004.

SE State-listed endangered
ST State-listed threatened
SCE State candidate for listing as endangered
SCT State candidate for listing as threatened

California Special Concern Species: it is the goal and responsibility of the Department of Fish and Game (DFG) to maintain viable populations of all native species. To this end, the Department has designated certain vertebrate species as "Species of Special Concern" because declining population levels, limited ranges, and/or continuing threats have made them vulnerable to extinction.

CSC DFG Species of Concern

DFG: Fully Protected Fully Protected species may not be taken or possessed without a permit from the Fish and Game Commission.

FP DFG Fully Protected

Endangered Species Act (ESA) Listing Codes: The listing status is current as of January 2004.

FE Federally listed endangered
FT Federally listed threatened
FPE Federally proposed endangered
FPT Federally proposed threatened
FC Federal candidate species
FSC Federal Species of Concern

3.0 REGULATORY RESTRICTIONS

Many government agencies have been designated jurisdiction over the Suisun Marsh at the federal, State, and local levels. Regulations restricting management activities alter management and therefore habitat composition and quality on managed wetlands. For instance, Figure 3 and Section 4.1 management schedules D, E, F, show the management changes required by intake restrictions to avoid listed species entrainment.

Appendix D discusses effects of regulatory actions on management of seasonal wetlands.

4.0 MANAGEMENT OPTIONS / TOOLS

Water managers must continuously adaptively manage their properties in order to achieve management objectives. The Suisun Resource Conservation District (SRCD) has developed two adaptive management strategies for both wintering waterfowl pond management and breeding waterfowl area management. (See Figures 4 and 5) The principles represented in these adaptive management strategies are discussed in more detail in the following sections.

Figure3. Water Management vs. Sensitive Species Presence in the Suisun Marsh

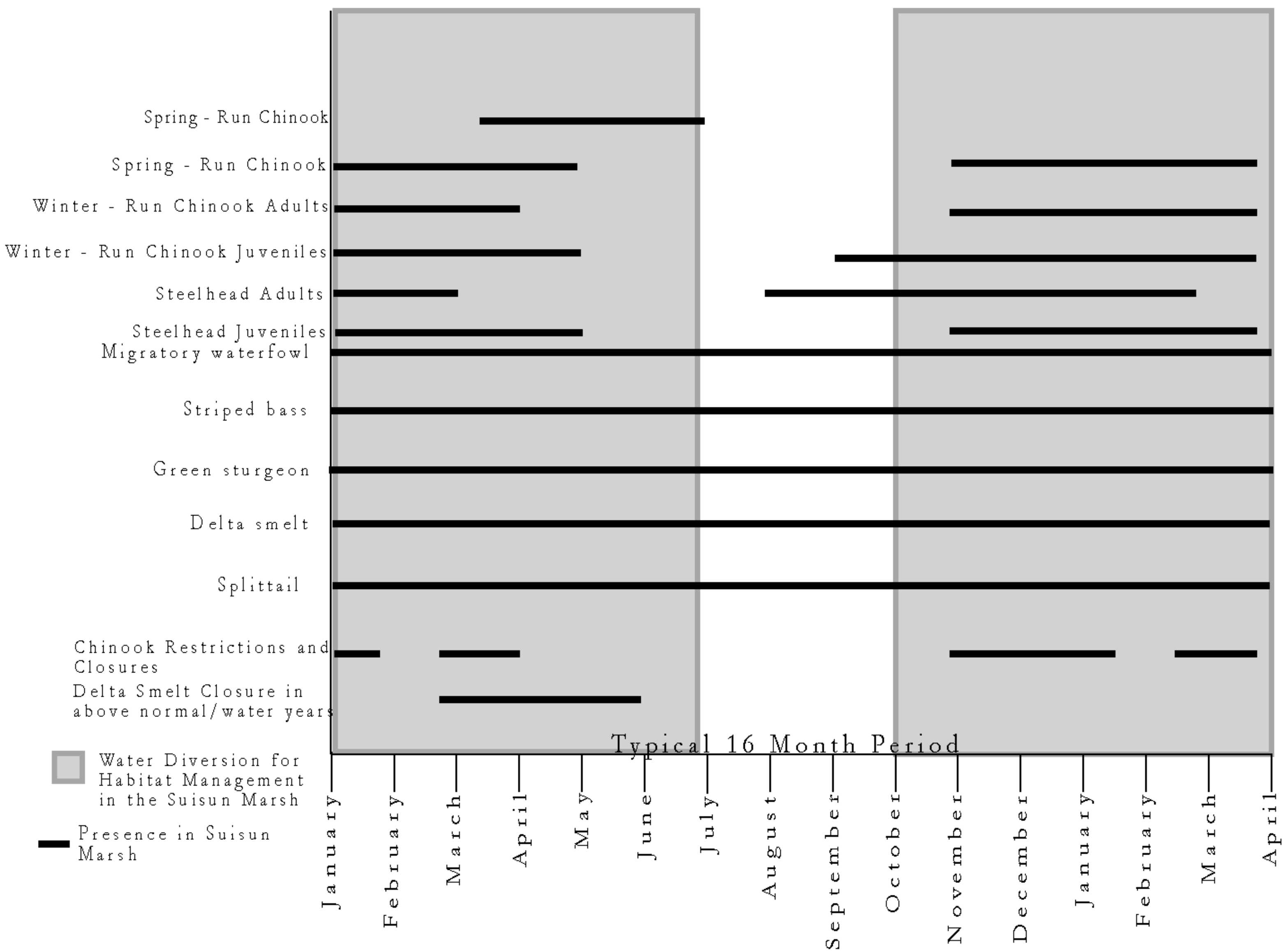
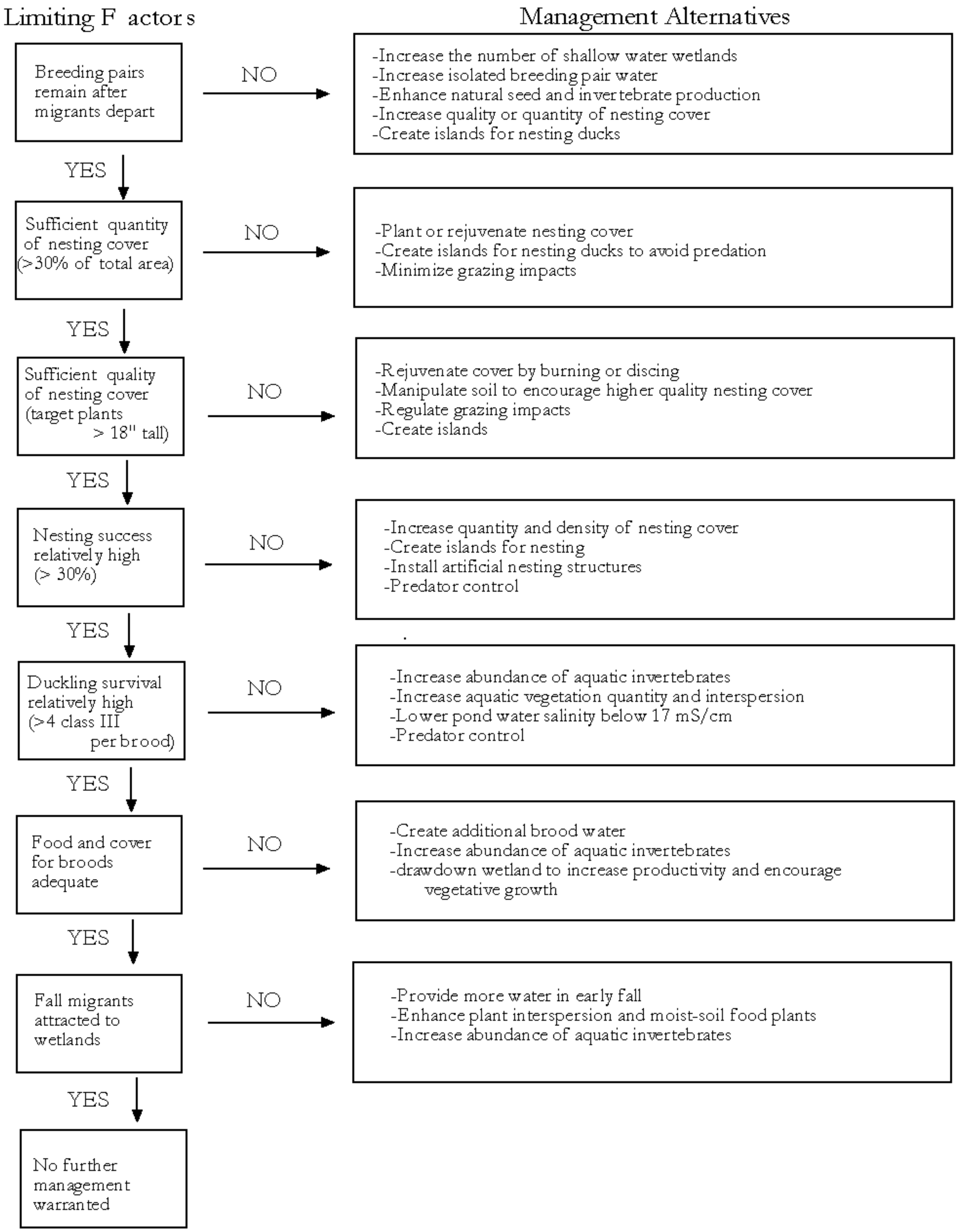


Figure 4. Wintering Waterfowl Pond Adaptive Management

Limiting Factors	Management Alternatives (if NO)
Ponds flood in (≤ 10 days) to winter level so that 50%- 60% is ≤ 12" deep	-Clean or widen ditches to allow for proper water flow -Cut new ditches to areas lacking proper water flow -Level intake structures and set at the correct tidal elevation -Move high ground into pond bottom sinks -lower water level to create feeding areas
YES ↓	
Pond water is clear and pond water salinity is relatively equal to channel water salinity	-Increase circulation -Clean or widen ditches to allow for proper water flow -Cut new ditches or V-ditch areas lacking proper water flow -Increase # of leaches to lower springtime soil salinity -Permanent pond for a year or more so soil salts and iron do not rise to the soil surface
YES ↓	
Ponds have suitable emergent vegetation and cover plants (30% for pintail 50% for mallards)	-Leave water on longer or change water schedule to target certain plant communities -Free float or plant tules in strategic positions -Increase # of leaches to lower soil salinity to support plant growth -Lower water levels during the growing season to allow germination -Permanent pond for a year
YES ↓	
Ponds have suitable seed and invertebrate producing plants (> 70%)	-Plant pond bottoms to grow moist soil food plants -Increase # of leaches to lower soil salinities to support target plant growth -Change water schedule to target certain plant communities -Lower water levels during the growing season to allow germination
YES ↓	
Ponds have appropriate waterfowl resting and loafing areas	-Check disturbance factors such as vehicle traffic -Lower shoot level to allow shallow water resting areas -Build loafing islands or low berms for waterfowl resting sites
YES ↓	
Ponds drain to below pond bottom in < 20 days	-Clean or widen ditches to allow for proper water flow -Cut new ditches to areas lacking proper water flow -Level drain structures and set at the correct tidal elevation -Move high ground into pond bottom to raise sinks -Increase number or size of drain structures
YES ↓	
Ponds reflooded to very shallow level ≤6" deep and target plants are germinating	-Lower water depth so plants can emerge and utilize oxygen -Increase # of leaches to lower soil salinities to support target plant growth -Move high ground into pond bottom to raise sinks -Plant pond bottoms to grow moist soil food plants -Circulate high volumes of water to lower pond water salinity
YES ↓	
Plants mature and produce seed	-Increase # of leaches to lower soil salinities to support target plant growth -Circulate high volumes of water to lower pond water salinity -Continue to hold water later into the year until seed maturation -Add water to prevent the soil from drying and causing soil salts to accumulate in the root zone
YES ↓	
No further management warranted	

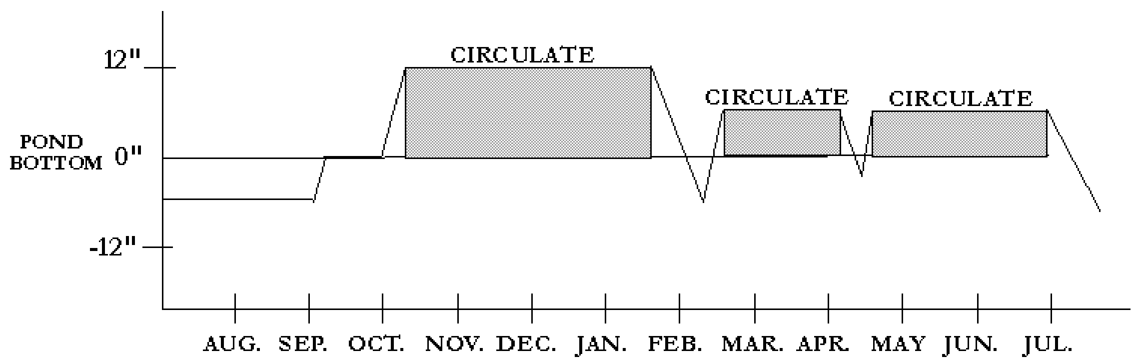
Figure 5. Breeding Waterfowl Area Adaptive Management



4.1 WATER MANAGEMENT SCHEDULES

Water management is the primary means for habitat managers to manipulate managed wetland vegetation communities in the Suisun Marsh. The Suisun Resource Conservation District (SRCD) has developed 11 water management schedules that typify management strategies used in the Marsh. These schedules are intended to be used as general models. Site-specific regulatory and physical conditions will influence actual management practices on individual properties.

A. No Intake Restrictions / Normal Flood Date / Long Hydroperiod



The "No Intake Restrictions/Normal Flood Date/Long Hydroperiod" schedule is designed for those properties unrestricted by Chinook salmon and delta smelt water intake restrictions and closures. Properties that might use this schedule are either not located in areas designated for species intake restrictions or are properties affected by closures but have fish screens on their intakes. Using this schedule, managers fill the ditches (without flooding the ponds) on September 1 and circulate new, less saline, water to remove higher salinity ditch water. The ponds are fully flooded on October 1 as quickly as possible to allow water to run over the soil surface to suspend surface soil salts and push deeper soil salts further down in the soil (SRCD, pers. communication). If time allows, the property is drained and reflooded to leach surface salts and decrease mosquito production (Haffner and Bruce, 2004).

Fully flooded ponds are not to be deeper than 12" over a majority of the pond when at winter level. During the waterfowl season (mid-October through late-January), circulation is maintained while water levels are held between 12" and 6" deep. During the season, it may be beneficial to lower pond levels to 6" to 8" deep, eventually bringing the water level back up to around 12" in December. Manipulating the water level can serve two purposes. First, exchanging high volumes of water can help regulate the natural soil salinities (Coiacetto, 1996). Secondly, manipulation of the water levels exposes additional edge habitat for feeding and loafing in areas of the pond that were previously flooded or too deep to be useful to wildlife, establishing additional wildlife habitat and waterfowl foraging habitat. This technique is used in early winter when high volume water exchanges are most effective at flushing salts and decaying plant materials. In late winter, water levels are raised utilizing the fresh water provided by rainfall. Circulation rates are maintained so that rainfall keeps the pond water level at the desired height.

In mid-January (or just prior to the end of waterfowl season) managers close pond intakes and begin to drain the ponds, initiating the first leach cycle. Each property will drain at a different rate depending on pond bottom elevation and topography, facilities, weather, and tides. Weather has a significant effect on pond drainage rates. Warm or windy weather will dry the soil faster while cold, calm and rainy weather can slow soil drying. The goal of draining the ponds is to achieve water levels 12" below pond bottom without letting the soil dry**.** Through the leaching process soils are not allowed to dry in order to avoid increased soil surface salinity and expose seedlings to possibly toxic soil salinities (Coiacetto, 1996).

After the first leach (drain), the pond remains at least at a mudflat stage to encourage seed germination. When necessary, the ponds are reflooded to approximately 6" deep, which should cover 50% to 60% of the ponded area at winter level. Water levels are kept shallow to allow for the greatest diversity of plant communities. Germination rates are highest from February to April, making low water levels critical during this time (O'Neil, 1972). Water is circulated as much as possible while keeping 50% to 60% of the ponded area covered. Moisture just beneath the surface of the higher ground will also provide suitable growing conditions for fat hen *(Atriplex triangularis),* purslane *(Sesuvium verrucosum),* brass buttons (*Cotula coronopifolia*), and pickleweed *(Salicornia virginica)* (Figure 6). Creating plant community diversity in the ponds is essential to providing suitable wildlife habitat for a diversity of species (Zedler, 2000).

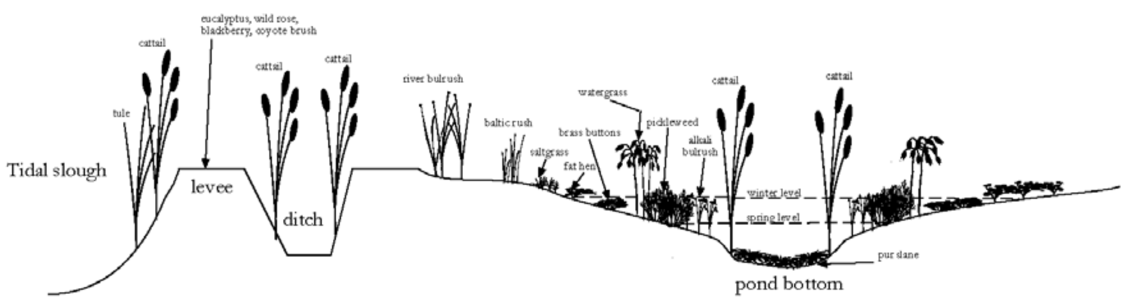
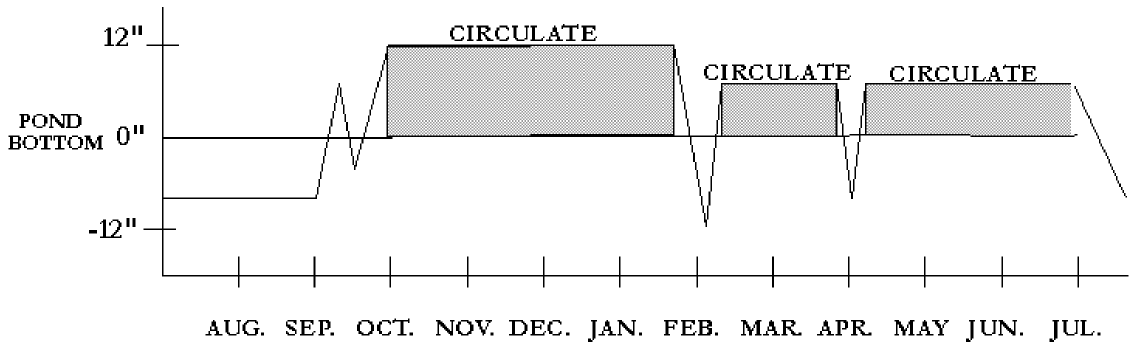


Figure 6. Schematic of typical long hydroperiod plants and elevation location

Around April 1 water is drained using the same drainage principals as used during the first leach, again the soils are not dried. If soils do dry, water can be brought back to the appropriate level with circulation. The timing of the final drain for summer is based on slough salinity and seed development. When slough salinity reaches 12 to 15 mS/cm circulation is ceased and the property is drained; the salinity standard for the Suisun Marsh in April and May is 11 mS/cm, therefore slough salinity should have little to no effect on the scheduling of the pond's drain cycle. If seeds have not yet developed, the soils are kept moist so plants will not become moisture stressed and cease seed production. Seeds production is the primary concern for timing the final drain of a pond.

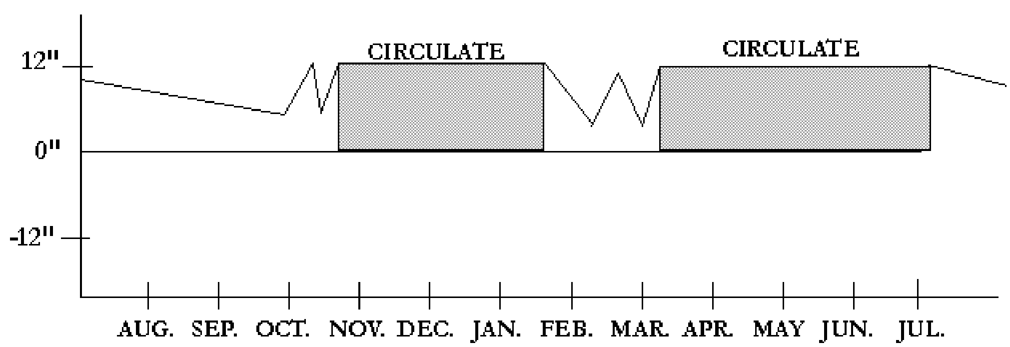
When seeds are mature, salinity becomes the critical and limiting factor in determining final drain timing.

B. No Intake Restriction/Early Flood/Long Hydroperiod



This water management schedule is virtually the same as “No Restrictions,” but after an early flood, properties are drained within seven days. The quick flood-drain time allows for a deeper leach without drying the soil and allows for a partial leach before winter. Leaching before winter will allow salts built up in the soil over the summer to dissolve and leach more easily from the soil. Leaching also acts as a mosquito control measure by killing the larvae and instar stages with water movement and drainage from the pond (de Szalay et. al., 1999). If the property is reflooded before the soil dries out mosquito reproduction may be reduced and the property may also avoid spraying by the Solano County Mosquito Abatement District (SCMAD) (Haffner and Bruce, 2004).

C. Permanent Pond/Brood Pond



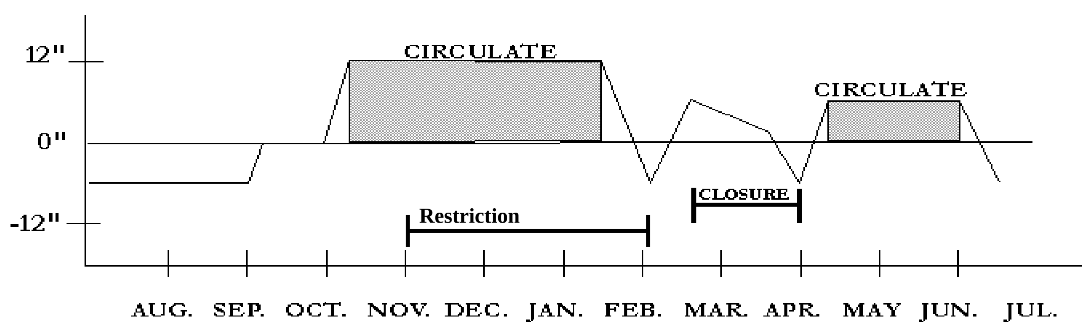
Managing an area as a permanent pond will result in establishment of submergent vegetation such as sago pondweed *(Potamogeton pectinatus)* and wigeon grass (*Ruppia martima*) for food and invertebrate production. Tall emergents such as cattail *(Typha spp.)* and tule *(Scirpus acutus)* will also become 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.

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). Permanent ponds are made available April through August when broods need water, cover, and food. Permanent ponds also provide habitat for molting adult waterfowl as well as resident populations of mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), and cinnamon teal (*Anas cyanoptera*).

Managing a pond with permanent flooding may reduce soil salinity (Kadlec and Smith, 1984; McKee and Mendelssohn, 1989), which can allow soils to recover and become more fertile. Since the soils do not dry when managed as a permanent pond, salts do not rise to the soil surface and into plant root zones creating the appropriate growing conditions for food and cover plants. Ponds are kept shallowly flooded to establish emergent cover. Tule root balls are allowed to float freely in pond also aiding in establishment of emergent cover. Food plants may grow on the shallow margins of the pond by maintaining low water levels. Maintaining low water levels may also encourage cattail growth that can eventually create wetland maintenance problems (e.g. overgrown ponds and ditches, etc.) (Grace, 1989; Rollins 1981).

D. Juvenile Winter-run Salmon Intake Closure/Long Hydroperiod/No Fish Screen



This water management schedule addresses need for an alternate management strategy where there are intake restrictions due to the presence of juvenile Chinook salmon. Like other management schedules, ditches are filled on September 1 without flooding the ponds and water is circulated through the ditches to flush out high salinity water. The ponds are fully flooded on October 1 as quickly as possible to allow water to run over the soil surface to suspend surface soil salts and push deeper soil salts further down in the soil (SRCD, pers. communication). If time permits, ponds are drained and flooded to leach surface salts (see "B. No Intake Restrictions/Early Flood/Long Hydroperiod").

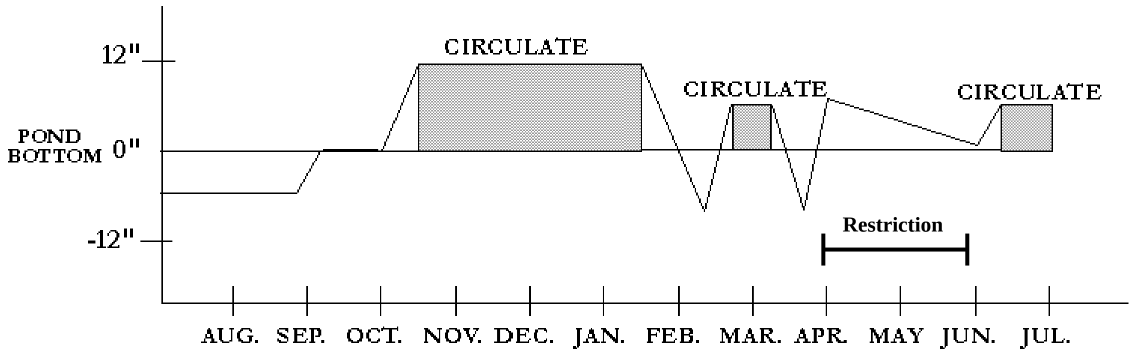
The ponds are flooded to winter level, no more than 12" deep over much of the pond. Water circulation is maintained while appropriate pond levels are also maintained. Throughout the winter, water levels may be manipulated by lowering the ponds to 6" to 8" deep, and then eventually bringing it back up to 12". During this time, from November 1 to the end of waterfowl season, managers cannot use more than 25% of their diversion capacity. The diversion capacity restriction decreases a manager's capability to efficiently circulate water while maintaining appropriate water levels.

In mid-January, intakes are closed and properties are drained. Properties vary in drainage rates depending on pond bottom elevation. If a property takes more than 20 days to drain, then the drainage process should begin the first weeks of January to allow time to drain the maximum amount of water before reflooding in February, though the timing of draining a pond should be conducted so as not to conflict with that pond's hunting interests. Timing the first drain is critical due to seedling susceptibility to increased salt toxicity when the pond is reflooded (McKee and Mendelssohn, 1989). The property is drained to 12" below pond bottom and maintained at that level without letting surface soils dry. If the soil does dry, the pond is reflooded to approximately 50% to 60% of the pond area at winter water levels. Before February 21st ponds are reflooded regardless of whether the ponds have fully drained. On February 21st all intakes are closed for the salmon closure.

The next 5 to 8 weeks are an important growth period for food and cover plants. Ponds are drained slowly during the salmon closure (February 21st to April 1st), but not allowed to drain completely before reflooding is allowed on April 1. Ideally, pond water levels have been drained to pond bottom by March 22nd to 29th. Then the ponds are drained as far below pond bottom as possible without allowing surface soils to dry. If the weather is hot, ponds are not drained below pond bottom until March 26th to 28th. On April 1, ponds are reflooded and water is continually circulated. Also on April 1, another diversion capacity restriction is instituted. From April 1 to May 31, managers may not use more than 35% of their water control structure diversion capacity.

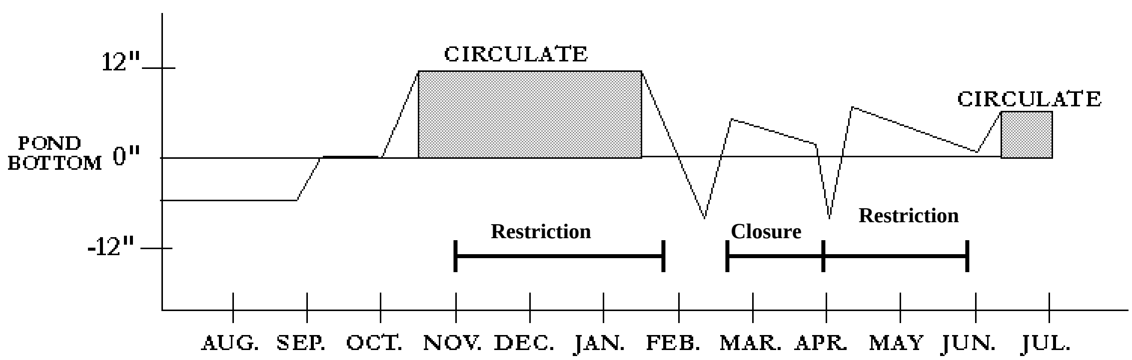
When slough salinity rises, if seed heads are still immature, the water is not drained to allow seeds time to develop. Once plants have germinated, they can tolerate slightly higher salinities. Once seed heads have developed ponds are drained for the summer so pond managers can conduct routine annual maintenance work and habitat enhancement projects

E. Delta Smelt Intake Restriction/Long Hydroperiod



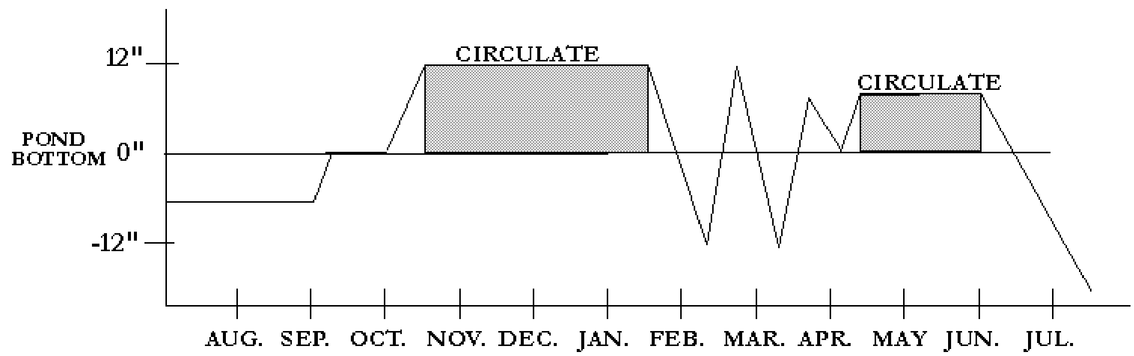
Delta smelt intake restriction is in affect April 1st to May 31st of each year. This water management schedule follows closely with "D. Juvenile Winter-run Salmon Intake Closure/Long Hydroperiod" until the end of the February. After the first water exchange in February, 50% to 60% of the ponded area at winter level is reflooded and water is circulated. The drainage process is initiated in early March to allow time to the exchange pond water and reflood before the intake restriction begins on April 1. Ponds are drained such that the pond water elevation is at mudflat in late May or at a low water level until a full drain in late May. This strategy maintains soil moisture for plant growth and germination during the intake closure. Beginning June 1st, 50% to 60% of the ponded area at winter level is reflooded and water is circulated. Ponds are drained for summer maintenance work when water salinity rises to unacceptable levels (12 to 15 mS/cm) or seed heads have matured.

F. Both Intake Restrictions/Long Hydroperiod



This management schedule is for areas of the Marsh that are subject to both the Chinook salmon and delta smelt restrictions. Landowners are given the opportunity to intake water until February 21. Landowners may begin to divert water April 1. From April 1 thru May 31 landowners can only use 35% of the water control structure's intake capacity. If during this time, two out of three CDFG 20 millimeter trawl survey sites predict delta smelt densities greater than twenty delta smelt individuals per 10,000 cubic meters over a two week sampling period, all diversions from designated sloughs shall use only 20% of their water control structure's intake capacity. These restrictions make it difficult for most managed areas to sustain a constant water level. As a result, ponds are drained slowly without allowing water levels to drop below pond bottom level prior to June 1. On June 1st, ponds are reflooded to 50% to 60% of the ponded area at winter level and water is circulated until available water salinity rises to 12 to 15 mS/cm or plant seed heads mature. Ponds are drained for summer maintenance when either of these thresholds is met.

G. Traditional Alkali Bulrush/Intermediate Hydroperiod



The traditional alkali bulrush (*Scirpus maritimus*) schedule follows the same principles as "A. No Intake Restrictions/Normal Flood/Long Hydroperiod". However, this management schedule calls for a second leach cycle instead of flooding and circulating water like in schedule "A". Leach cycles also differ in that water is leached to 12" below pond bottom for two one-week periods.   During the leach cycles, soils should be kept moist. Soil moisture for plant germination is critical to getting lush stands of bulrush and other wetland vegetation such as fat hen, watergrass (*Echinochloa crusgalli*), purslane, brass buttons, swamp timothy (*Crypsis schoenoides*) and pickleweed (O'Neill, 1972; Rollins, 1981) (Figure 7). Diversity in plant communities is the key to providing suitable habitat for a diversity of wildlife species (Bias et. al., 2000; Fredrickson and Laubhan, 1994).

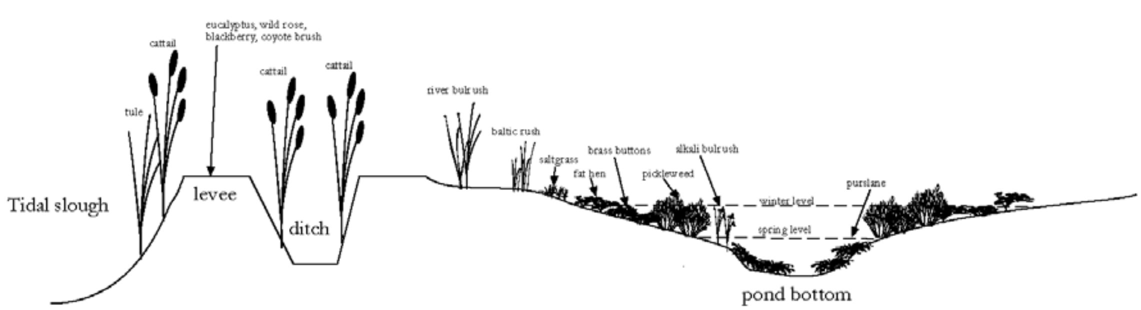
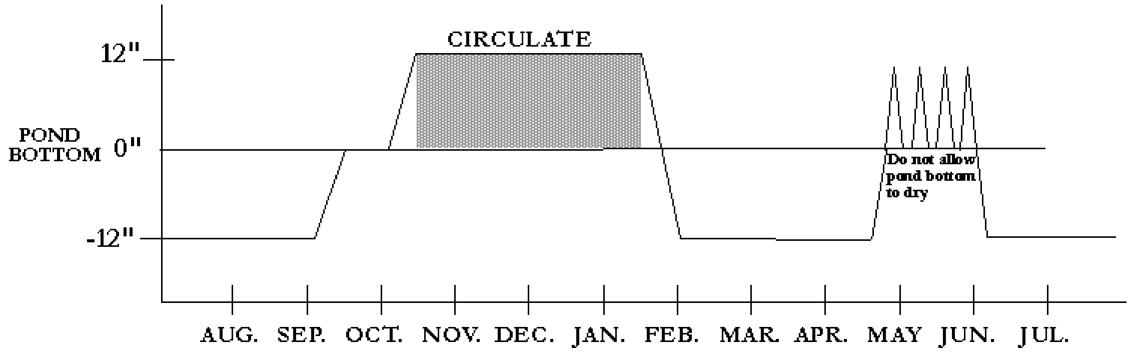


Figure 7. Schematic of typical intermediate hydroperiod plants and elevation location

H. Traditional Watergrass



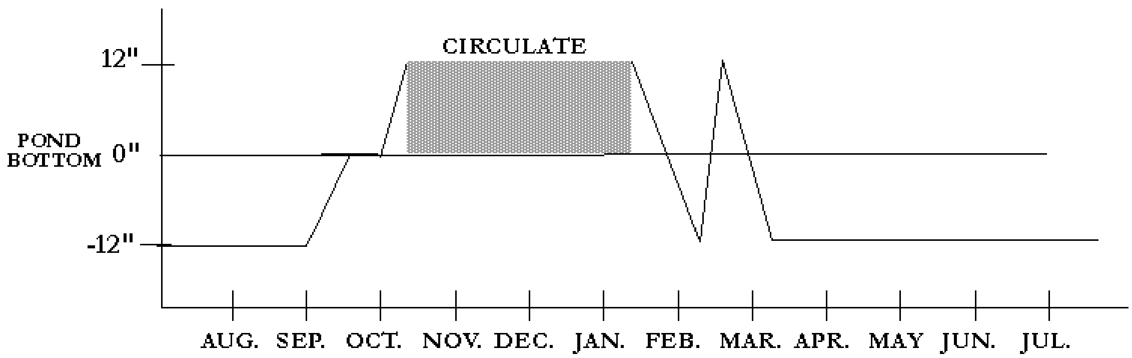
Traditional watergrass management schedule is not recommended unless the water quality is excellent (under 7 mS/cm) and pond soil salinity is extremely low (under 7 mS/cm). High water quality is needed because this water management schedule does not allow for a leach cycle to drain excess salts from the property. Under this schedule, water is drained in mid-January and the soil is allowed to dry to the point of cracking. Two purposes are served by allowing the soil to dry. First, allowing the soil to dry discourages growth of competitive plants and second, it allows equipment to lightly disturb the soil to prepare the seedbed. Watergrass germinates late in the year in moist soils that have low salinity (Rollins, 1981). Competition by early germinating plants is avoided by draining the properties at the appropriate time.

The ponds are reflooded in April and are irrigated several times between April and June. Traditionally properties are irrigated four times, which can result in tall dense stands of watergrass. Seasonal water-level fluctuations can affect seed germination, plant growth, and productivity (Gerritson and Greening, 1989; David, 1996). A denser stand of watergrass is encouraged by irrigating the area a greater number of times to encourage growth of new shoots. If a property is irrigated only twice, it is likely the plants will likely be 2 to 4 feet high instead of 6 to 8 feet high. Irrigating twice in a season is a more useful management technique because the shorter plants allow the seed heads to be more accessible to waterfowl.

This water management schedule is not recommended for most Suisun Marsh managed wetlands for several reasons. The primary concerns with using this management schedule in Suisun are related to salinity issues. For example, without a leach cycle, soil salinities will rise above natural levels creating an inhospitable environment for seed germination of desired plant species (Rollins, 1981). Also, properties that use this management schedule must able to drain completely in short order. Watergrass is a grass that cannot tolerate long periods of inundation.

Use of the watergrass water management schedule in Suisun may promote mosquito production by flooding previously dry areas where mosquitoes have laid their eggs. It takes approximately ten days for the mosquito egg to develop into a flighted, adult mosquito (Mosquito Notes). It is for this reason that irrigated ponds must be able to flood and drain in less than ten days. If drainage can be completed prior to adult mosquitoes taking wing, the larvae and pupae are flushed out of the pond with the drain water into the main sloughs where naturally occurring predators can eat the larvae (Haffner and Bruce 2004).

I. Traditional Fat hen/Short Hydroperiod



The fat hen schedule is based on a short hydroperiod that inundates the property for less than six months. The short hydroperiod allows salts to rise to the surface, which prevents less salt tolerant plants from germinating and creates a competitive advantage for salt tolerant fat hen and pickleweed. Both elevation and salinity can give fat hen a competitive edge over less salinity tolerant pond bottom plants. Fat hen areas should be disced or mowed every 4 to 5 years to remove decaying vegetation and control undesirable plants such as saltgrass. Disturbing the soil will create a competitive advantage for fat hen and also create favorable conditions for brass buttons (Rollins, 1981).

Traditional fat hen management limits plant diversity to a couple of salt tolerant species, whereas similar fat hen plant densities can be achieved with more diverse plant communities by using a longer hydroperiod. To achieve a diverse composition of plants and have stands of fat hen, an alternate water management strategy is used where the water is kept at half winter level. Using this strategy, the upper margins of the pond will grow fat hen and pickleweed due to the short hydroperiod (5 to 6 months) (Figure 8). If the wetlands are managed properly through hydroperiod and topography, diversity can be achieved.

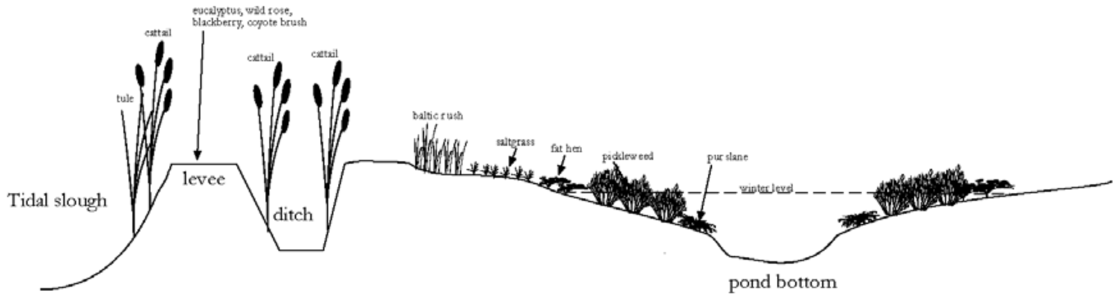
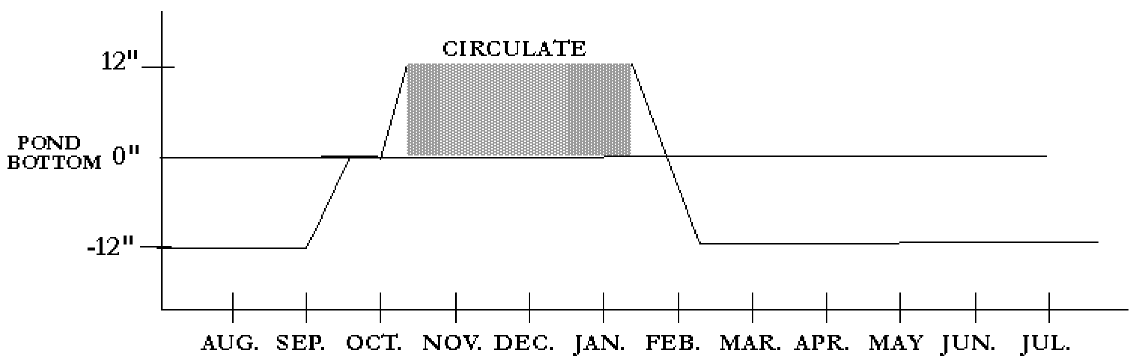


Figure 8. Schematic of short hydroperiod plants and elevation location

J. Pickleweed Schedule

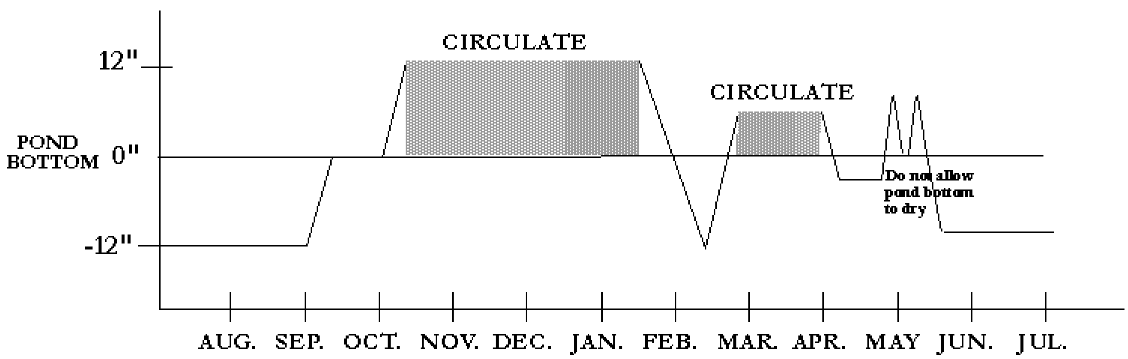


Areas of pickleweed habitat within the managed wetlands provide numerous waterfowl and wildlife values. Omnivorous waterfowl species such as wigeon, gadwall, green-winged teal, and northern shoveler utilize pickleweed seed, the populations of invertebrates it supports, and use it as cover in open ponded areas (Burns et. al., 2003). Pickleweed and associated salt-tolerant plants also provide important habitat for the endangered salt marsh harvest mouse (Shellhammer et. al., 1982; Geissel et. al., 1988). Maintaining and supporting areas of pickleweed within managed wetlands will provide habitat for this endangered species, while also providing habitat attractive to waterfowl.

The pickleweed schedule is based on a very short hydroperiod with minimal or no leach cycles. In January properties are drained below pond bottom encouraging salts to rise to the soil surface. Pickleweed will grow in saline pond bottoms where other beneficial plants may not be able to tolerate the high salinity levels (Pennings and Callaway, 1992). With higher soil salinity, other less salt tolerant plants will be unable to out-compete pickleweed. Pickleweed growth may also be encouraged by applying water in late summer when the channel water salinities at their highest. Summer irrigations are shallow water applications applied only to those ponds that have good drainage capabilities to avoid mosquito production. Other wetland management strategies can also establish pickleweed and fat hen on pond peripheries where the pond bottom is flooded in winter but dry in spring.

The pickleweed management schedule has the potential to increase soil salinities to levels where salinity negatively impacts pickleweed. In such cases, soil salinities can become so high that patches of bare ground form in the pond bottom. Depending on the salinity of the water applied to the managed wetland, soil salinities can increase gradually over time or may increase quickly in times of drought. Excessive salt accumulation can be minimized through water management activities such as high circulation rates in the fall or by completing a partial leach cycle in the spring. Modifications of water management activities are reassessed annually based upon vegetative responses and habitat quality to management activities (Figure 8).

K. Modified Watergrass/Erratic Hydroperiod



This is the same schedule as "H. Traditional Watergrass," but options are not as limited if the channel water salinity rises. The leach and circulation cycles after hunting season will flush salts that have deposited during fall flooding. Typically the water in late winter is fresher and will have a higher salt dilution potential when flooding the wetlands. The channel water salinity should be less than 7 mS/cm for successful watergrass management. Water can be drained as soon as late March, so watergrass irrigation can occur earlier in the year when channel water salinities are lower. This schedule is unlikely to result in a mono-typical stand of watergrass, but will promote plant species diversity (including swamp timothy, etc.). Two watergrass irrigations in May will encourage a short, non-uniform stand of watergrass in areas with low salinities.

The primary concern with the modified watergrass management schedule is the potential for mosquito production. The fluctuations in water levels will create mosquito-breeding areas (de Szalay et. al., 1999). When the water level is brought up, eggs laid on the mud hatch. Unless the area is drained quickly, mosquito production may warrant spraying by SCMAD.

This schedule will also encourage alkali bulrush growth if channel water salinities remain too high for watergrass irrigation.

Conclusion

There are many factors dictating the optimal water management schedule for the specific property. Whatever water management schedule a property manager chooses, they must take into account many variables and be flexible in carrying out their schedules. Each landowner must apply an adaptive management strategy that may change monthly or yearly to best manage their property.

4.2 VEGETATION MANAGEMENT / MANIPULATION

Land managers use vegetation manipulation, in conjunction with water management, as a tool to create a mosaic of habitats desirable to waterfowl species. Manipulation may include, but is not limited to, planting, herbicide treatment, flooding, burning, discing, and mowing. The landowner is responsible for obtaining any necessary permits, observing regulations, and notifying the appropriate agencies. Descriptions found in Appendix E are current management practices and recommendations on Suisun Marsh managed uplands and wetlands.

5.0 EXPECTED RESULTS AND BYPRODUCTS OF MANAGEMENT

5.1 BENEFITS OF MANAGEMENT

Wetland management in Suisun relies on the following principles: Hydrologic change influences plant community composition and structure, thereby affecting the availability of waterfowl food (Fredrickson and Laubhan 1994). The quality, abundance and availability of resources, as well as spatial arrangement of different wetland types that provide such components, are critical factors that determine abundance and biodiversity of wetland wildlife (Fredrickson and Laubhan 1994).

By using these principles wetland managers can have the greatest effect on food resources and resulting wildlife use through manipulating water. Diverse wetland types and their spatial arrangement in the region determine the level of wildlife use. Dynamic wetlands supply a variety of food resources that allow waterfowl to feed selectively and to obtain nutritionally adequate diets from a variety of sites (Fredrickson and Reid 1988). In Suisun it is the diversity of habitats and the variety of foods they produce that attract up to 28% of the wintering waterfowl in California and many resident waterfowl.

Wetland managers maintain and improve local upland areas for resident breeding and nesting waterfowl where appropriate. Upland fields in the Suisun Marsh (specifically Grizzly Island Wildlife Area) are productive mallard nesting areas (McLandress et. al. 1996). Current management strategies maintain and enhance waterfowl nesting and brood habitats to promote local waterfowl production. More than 60% of the mallards harvested in California originate from breeding areas in California. Factors limiting mallard numbers in California are related to the quantity and quality of mallard nesting and brood rearing habitats (California Waterfowl Association, 2003).

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.

Habitat management can also create essential breeding habitat for shorebirds. Breeding shorebirds nest in a wide range of habitat from unvegetated wetland flats to moderately tall, dense upland grasses. For many breeding shorebirds, landscape juxtaposition of habitats is important. Temporary ponds are important early in reproduction, whereas seasonal, semi-permanent, and brackish wetlands provide foraging habitat throughout nesting and brood rearing (Eldridge 1992). Spring drawdowns practiced by Suisun Marsh wetland managers in conjunction with upland areas provide ideal foraging conditions for migrating shorebirds.

Managed wetlands and associated upland areas provide habitat for many mammal species. Most of the common mammals found in the Suisun 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.

In addition to benefiting wildlife, Suisun Marsh managed wetlands provide benefits to the surrounding community. Hunters spend approximately 50,000 hunter days each waterfowl season. Specifically on public lands, hunts for waterfowl, pheasant, junior waterfowl, junior pheasant, elk, pig, rabbit, and falconry total 11,232 hunter days. Nature study, bird watching, and photography are recreational pursuits that have been increasing in the past few years. It is estimated that some 19,500 recreational use days are spent on public lands in the Marsh annually engaging in these activities. (pers. comm. Grizzly Island Wildlife Area 2002)

Despite challenges and constraints such as aging facilities, threatened and endangered species regulations, subsidence, mosquito abatement, and salinity issues, managed wetlands in Suisun Marsh provide a valuable resource for both wildlife and people.

5.2 POSSIBLE UNINTENDED CONSEQUENCES OF MANAGEMENT

While managed wetlands in the Marsh provide valuable habitat for many wildlife species, there are some unfavorable conditions that may be associated with the management of wetlands.

5.2.1 Fish Entrainment

Fish may be diverted by unscreened managed wetland intakes and possibly entrained on the property. It is unknown whether the fish are truly entrained or are able to exit ponds through drains. It is also unknown if all entrained fish die as a result of entrainment or if they may grow and be reproductively successful in managed wetlands (i.e. splittail, striped bass). The assumption that fish are entrained has lead to the current regulatory restrictions on unscreened managed wetland diversions in the Suisun Marsh. The impacts to fish populations under current regulatory restrictions by diversions in Suisun are unknown. Current regulatory restrictions are a constraint to optimal seasonal wetland management.

5.2.2 Discharge Issues

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. 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 dissolved oxygen (DO) events in small, dead-end sloughs adjacent to managed wetlands.

In an unpublished paper dated October 18, 2004, Schroeter and Moyle present data documenting low DO events in sloughs. Low DO events may be associated with dark to black water being discharged from managed wetlands. This observation had led the authors to believe discharges from managed wetlands have caused the observed events. Low DO events coincide with fall flood up discharge activities when temperatures are high, circulation rate is low, and there is a large amount of dead broad-leaved vegetation on the pond bottom.

Low DO events have been associated with black water smelling of sulfides. U.C. Davis field researchers have noted dead fish and invertebrates in these areas resulting in concern for local and migratory fish populations. Impacts to other wildlife species have not been noted.

5.2.3 Acid Sulfate Syndrome / Red water

Acid sulfate reactions in soils high in iron result in the build up of sulfuric acid in the soil (see Appendix F for graphic of process). Only certain types of iron rich soils are prone to this process. These soils can become acidic enough to be toxic to plants resulting in bare patches in ponds. Typical wetland management may exacerbate the condition when ponds are flooded, drained, and dried causing oxidation and reduction of soils. (DWR 2001)

A multi-agency study found that dabbling ducks did not avoid ponds with red water (USGS 1999). However, once ponds develop bare patches waterfowl use would be expected to decrease.

5.2.4 Subsidence

As stated in Section 2.1.5, there are several factors that contribute to subsidence of peat soils. Typical management actions taken in Suisun can create conditions allowing for subsidence on managed wetlands. Alternating wetting and drying, as prescribed by most management plans, can cause shrinkage and oxidation of soils. Drying and tilling soils also makes them vulnerable to wind erosion. Fortunately these conditions are only seasonal in typical management regimes. Soils on most managed wetlands are subjected to subsidence causing conditions for only a few months per year making subsidence rates in Suisun much lower than areas with similar soils like the Delta.

6.0 UNCERTAINTIES AND DATA GAPS

6.1 FISH AND WILDLIFE UNCERTAINTIES

6.1.1 Waterfowl Uncertainties

- Waterfowl food availability and densities on managed wetlands
- Waterfowl food preferences
- Duckling habitat use and the effects of salinity on ducklings
- Effects of tidal restoration on waterfowl populations
- Regional habitat availability effects on indicators of waterfowl use in Suisun
- Is it possible to increase the carrying capacity of managed wetlands for waterfowl under current regulatory restrictions?
- Will increasing carrying capacity for wintering waterfowl on managed wetlands enhance other wildlife values?

6.1.2 Other Fish and Wildlife Uncertainties

- Effects of tidal restoration on salt marsh harvest mouse (SMHM)
- Need to quantify the current use and density of species inhabiting managed wetlands
- Managed wetland habitat value to SMHM populations
- Do fish screen affect foraging of waterbirds on managed wetlands?
- Impact of wetland management on birds nesting in wetland areas
- Use of the Marsh by bat species – how, when, what species?
- Effects of mosquito control and management on bat populations
- Distribution of Suisun shrew on both managed and tidal wetlands of Suisun
- Possible impacts of wetland management on the Suisun shrew
- Impacts to fish species by drain water conditions (i.e. organic matter, low DO)

- Impacts to fish species by unscreened diversions with current regulations on diversions
- Impacts to managed wetlands by pigs

6.2 HABITAT UNCERTAINTIES

- Relationship between applied water salinity and plant community composition and growth (pore water salinity)
- Effects of pollutants on food production

6.3 PHYSICAL UNCERTAINTIES

- Subsidence –
  - How; what is the mechanism?
  - Where in Suisun Marsh?
  - Specifically, where in a managed pond does subsidence take place?
  - How much subsidence is there and at what rate does it occur in Suisun?
  - What is the importance of drying ponds in August to September?
- Leaching efficiency of applied water
- Effects of managed wetland drainage water on ambient water quality
  - Role of managed wetlands in dissolved organic carbon and methelated mercury production
  - Relationship between low dissolved oxygen events and management of wetlands
- Re-suspension of sediment by wind and wave action
- Does placement of mineral sediment onto peat soil cause subsidence?
- The effect of management strategies on soil chemistry
- Relationship between internal recirculation of water and sedimentation
  - What is the source of sediment in internal ditches?

7.0 OPPORTUNITIES / FUTURE POSSIBILITIES

This section presents ideas for overcoming the constraints presented by aging facilities, subsidence, threatened and endangered species regulations, and mosquito abatement.

7.1 FACILITIES

In the past, wetland managers have been given the opportunity to make habitat improvements that might not have been economically feasible if not for cost-share opportunities provided by the California Department of Fish and Game, the Bureau of Reclamation, Ducks Unlimited, California Waterfowl Association, and others. Even with those opportunities, there are still facilities throughout the Marsh that need improvement. Those facilities described in Appendix A all need periodic maintenance to perform efficiently and maintain target habitats. Improvement of the structures outlined below could help wetland managers enhance wetland values on their properties.

7.1.1 Pumps

Properties with low average pond bottom elevations are difficult to drain completely by gravity alone. Pumps may be necessary to facilitate complete drainage of these ponds. Properties with severe exterior siltation problems generally have a permanent pump (electric or diesel) for drainage because the silt buildup either physically blocks tide gates from opening or blocks gravitational drainage by raising drainage slough bottom elevations. Other ponds that can only drain when tides are low enough might use a portable pump to facilitate drainage when drawdown schedules do not coincide with adequate tides. Future considerations should look into placing pumps into areas that would benefit the drainage capabilities of several properties (i.e., Frost Lake).

Because of siltation and the potential for subsidence, dredging should be looked at as a possible way to combat this problem. Currently, under the U.S. Army Corps of Engineers Regional General Permit, dredging material from exterior bodies of water is not permitted. Although, the San Francisco Bay Regional Water Quality Control Board Staff Report in May 2000 on the *Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines*, listed restoring appropriate elevations to subsided diked baylands and levee maintenance as beneficial uses/reuses of dredging.

7.1.2 Interior Levees

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.

7.1.3 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.

7.1.4 Pipes

Many managed wetlands in the Suisun Marsh still use corrugated metal pipes (CMP) to regulate water levels within their ponds. Smooth wall plastic pipes are currently being 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 in excess of 50 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.

7.2 SUBSIDENCE REVERSAL

Subsidence is defined as the collapse of soil layers caused by the oxidation of organic soils. Some subsidence is presumed to occur in the Suisun Marsh but has not been documented. Rates of subsidence documented in the Sacramento-San Joaquin Delta region range from 1-4 inches per year. Large loss of soil can affect hydrology and ecology by lowering pond bottoms to the point of making them hard to drain by gravity and may require pumping to drain completely.

Reducing discing frequency and reflooding fallow fields to maintain a high water table may slow this process in the Suisun Marsh. As mentioned in Section 7.1.1, dredge material could be used to restore subsided areas to historical elevations.

7.3 MULTI-SPECIES MANAGEMENT

Consistent with the ecosystem approach, multi-species management is an integral part of the Suisun Marsh wildlife manager's job. Any action taken to enhance current managed wetland functions will aid multiple species.

For instance, shorebirds, like waterfowl, rely on wetlands throughout the year. Habitat losses highlight the need for management of breeding and migrating shorebirds including American avocet, killdeer, black-necked stilt, spotted sandpiper, willet, common snipe, marbled godwit, long-billed curlew, and Wilson's phalarope on public and private lands in the Suisun Marsh. By enhancing current wetland management, habitat for shorebirds and waterfowl will be enhanced.

Outside of enhancing managed wetland structures, another alternative to manage for multiple species would be to allow wetland managers to section off areas within their managed wetlands to be managed specifically for threatened and endangered species. Multiple species could also benefit by allowing wetland managers unrestricted access to water during fresh water periods. Then later in the year the Marsh would be allowed to become saltier for those species that need variable salinity regimes. While this option does not change conditions on managed wetland properties for multiple species, it does consider managing the Marsh as a whole for both waterfowl and tidal wetland species needs.

7.4 FUTURE RESEARCH / STUDIES

A full list of research needs can be found in Section 6.0 Uncertainties and Data Gaps. In terms of implementing changes in wetland management to affect subsidence or encourage a diversity of species on managed wetlands, the immediate research need is to collect baseline data. Baseline data of the abundance and diversity of species using managed wetlands is needed to assess the success of any management changes. The same is true of implementing subsidence reversal techniques. We need to have a baseline rate of subsidence in areas where subsidence reversal techniques will be used to evaluate their success. Monitoring the baseline and response to management change should be the first priority on managed wetlands.

Appendix A

Primary Water Control Structures Used on Managed Wetlands in Suisun Marsh

A-1 LEVEES (Exterior/Interior)

Exterior levees are embankments that prevent uncontrolled flooding of marshland due to tidal action. Exterior levees allow for management of water outside and inside the managed wetland (see Levee Conceptual Model). The crown of these levees is optimally about 9 feet above zero tide with a 12-foot top width. Exterior levees are used in conjunction with interior levees, ditches, and water control structures to control water on the land they surround.

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.

There is routine repair and maintenance required on exterior and interior levees. Typical levee maintenance work includes restoring levee contours, levee resurfacing, repair of gates and other hydraulic structures, mowing vegetation, discing levee soils, and embankment repair (Ramlit 1983). Typical causes of levee maintenance problems include storm events, wave action, levee subsidence, and rodent damage (DWR 2001). The minimum standards for the repair and maintenance of existing levees are as follows (SRCD 1980):

> For exterior levees, the levee contours shall be restored to match the previously existing levee cross section. If the existing side slope is eroded beyond 1.5 foot rise to a 1 foot run (1.5:1), the slope should be rebuilt to 2:1. Coring should be done only where required to repair damage from animal channels or eliminate seepage.
>
> For interior levees the levee contours shall be restored to match the previously existing levee cross-section. If the existing side slope is eroded beyond 1.5:1, the slope should be rebuilt to 2:1. Coring should be done only where required to repair animal channel damage or eliminate seepage.

A-2 DITCHES (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)

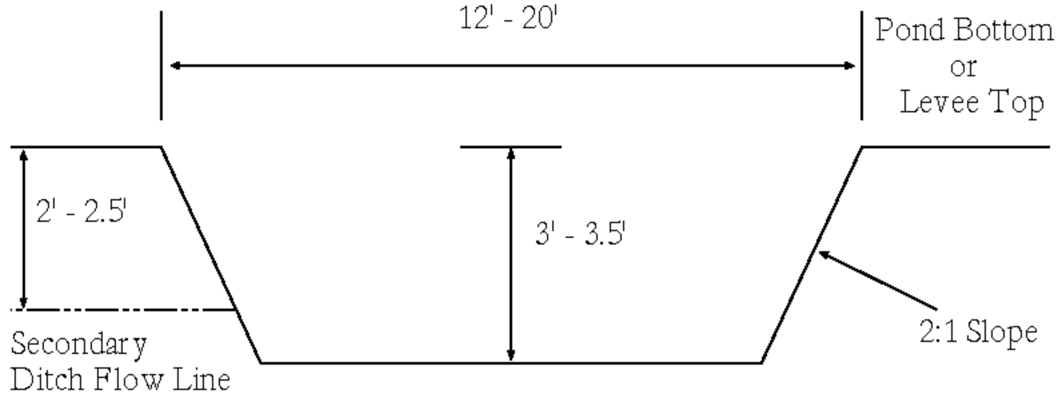


Figure A-1. Cross Section of Primary Ditch

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).

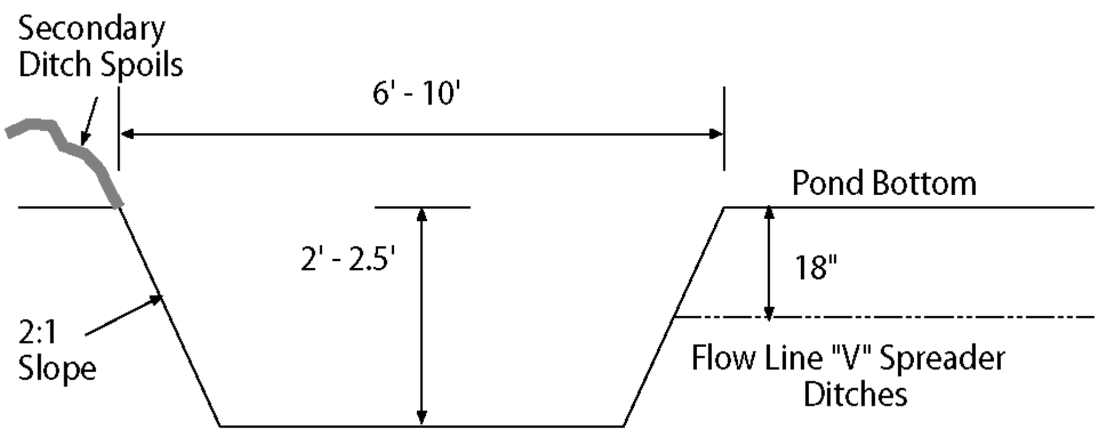


Figure A-2. Cross Section of Secondary Ditch

“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)

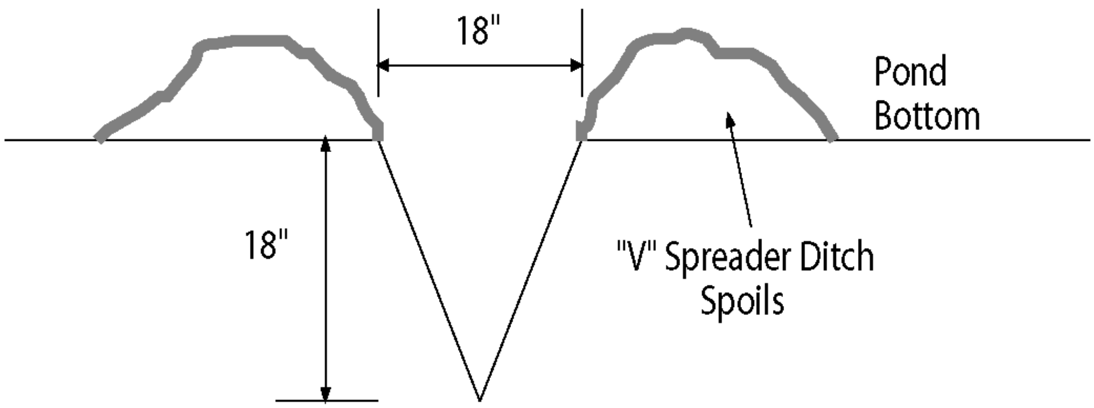


Figure A-3. Cross Section "V" Spreader Ditch

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).

A-3 WATER CONTROL STRUCTURES (Culverts/ Gates/ and Risers)

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, except risers and weir boxes, are constructed from stainless steel, plastic or asphalt coated galvanized, or alclad steel meeting the requirements of Interim Federal Specification WW-P-405 (SRCD 1980).

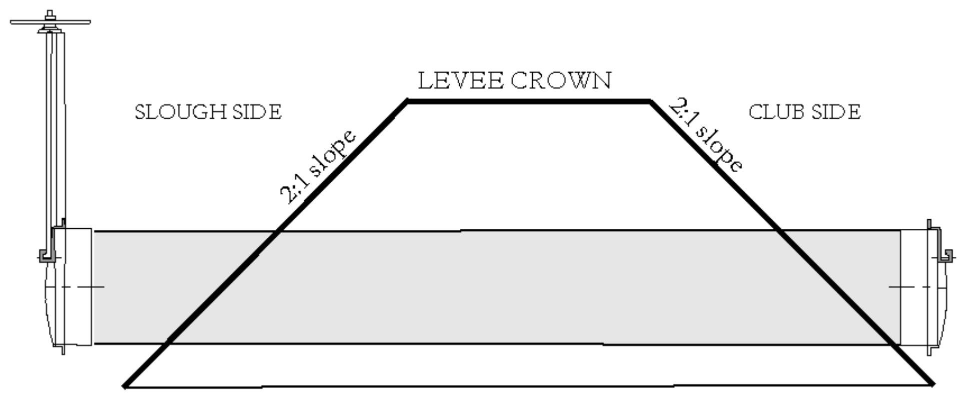


Figure A-4. Typical Exterior Levee Section For a Flood Gate

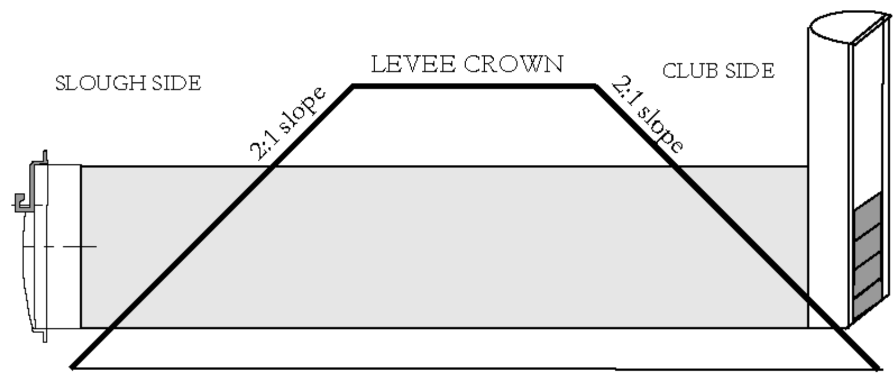


Figure A-5. Typical Exterior Levee Section For a Drain Gate

The six most commonly used water control structures used for flooding and drainage of ponds are culverts, flap gates, slide/flap gates, screw gates, flashboard risers, and flashboard boxes. These structures and their purposes as described by Rollins (1981) are discussed below.

Culverts are corrugated steel or plastic pipes placed in a levee for the purpose of conveying water from one side of the levee to the other (Rollins 1981). (Figures A-4 and 5) Exterior culverts should be 12 gauge steel or heavier whereas interior culverts should be 14 gauge steel or heavier (Rollins 1981).

Flap gates are hinged wooden or metal covers affixed to the end of culverts or redwood boxes. 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 A-6)

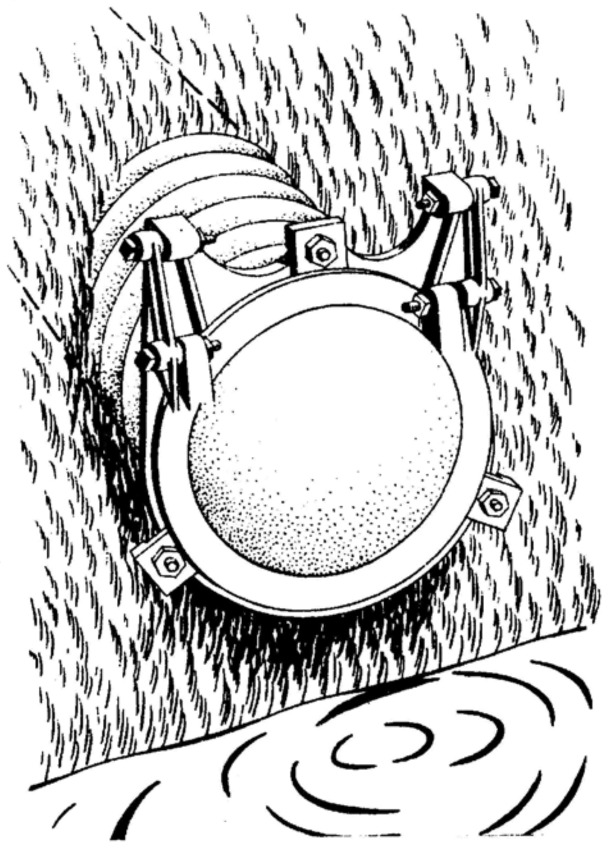


Figure A-6. Simple flap gate (Rollins 1981).

Slide/flap gates, also called screw/flap 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. Slide/flap gates are nearly always installed on the outboard side of levees and in combination with 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 A-7)

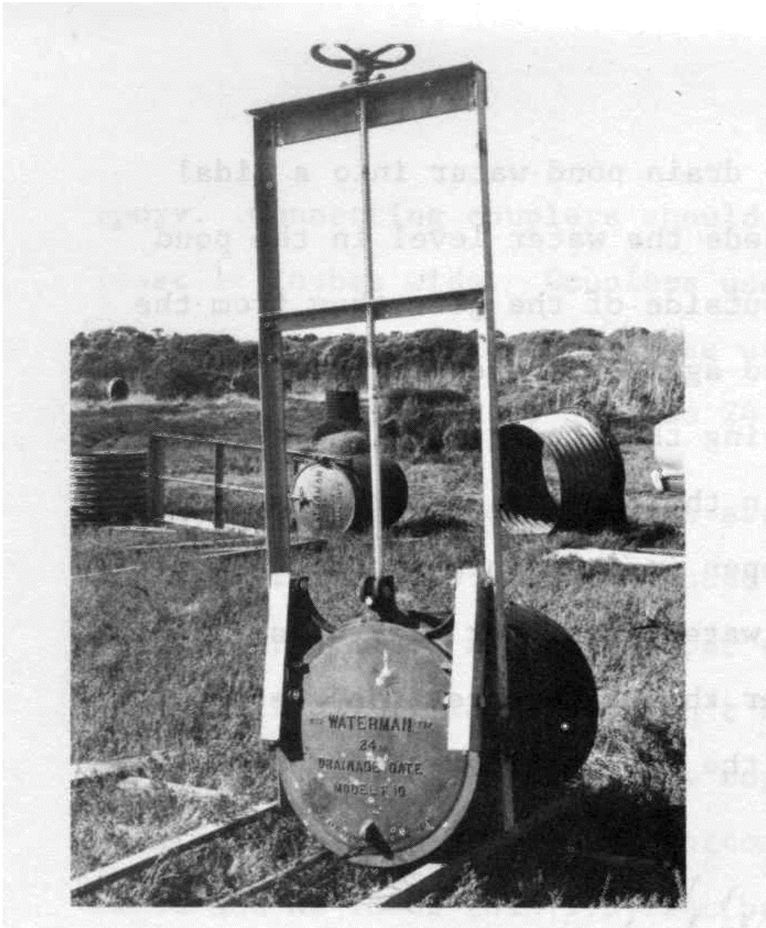
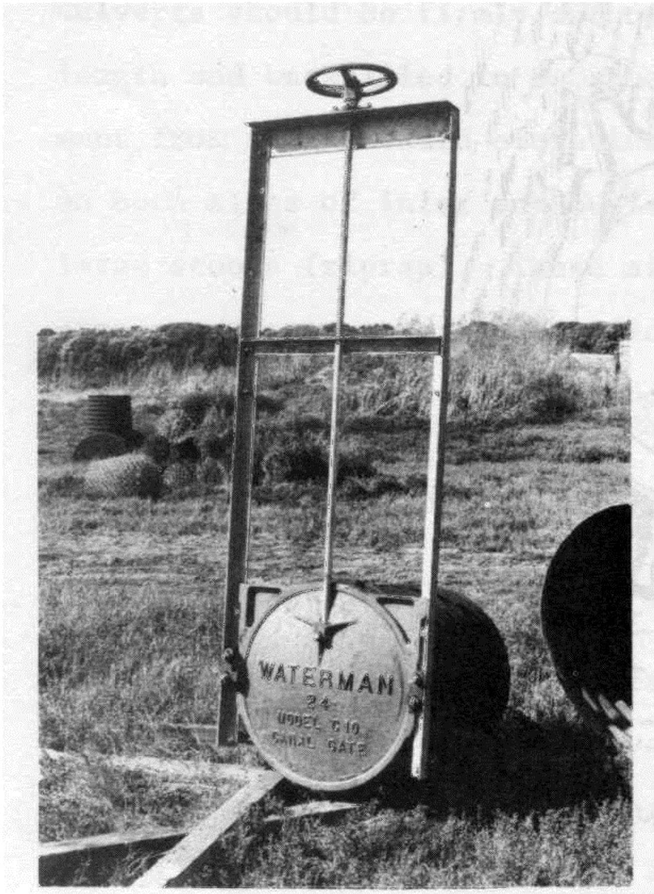


Figure A-7. Slide flap gate. Photo by D Dick (Rollins 1981).

Slide gates, also called 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 slide/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 A-8)



Slide gate. (photo by D. Dick)

Figure A-8. Slide gate. Photo by D. Dick (Rollins 1981).

Flashboard risers consist of a length of corrugated metal pipe cut in half longitudinally and placed vertically on top of the inboard end of an inlet or outlet culvert. The bisected culvert is fitted with grooved metal frames on each side. Wooden planks are inserted one on top of the other into the grooved frame, thus preventing water, except that which spills over the planks, 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 A-9)

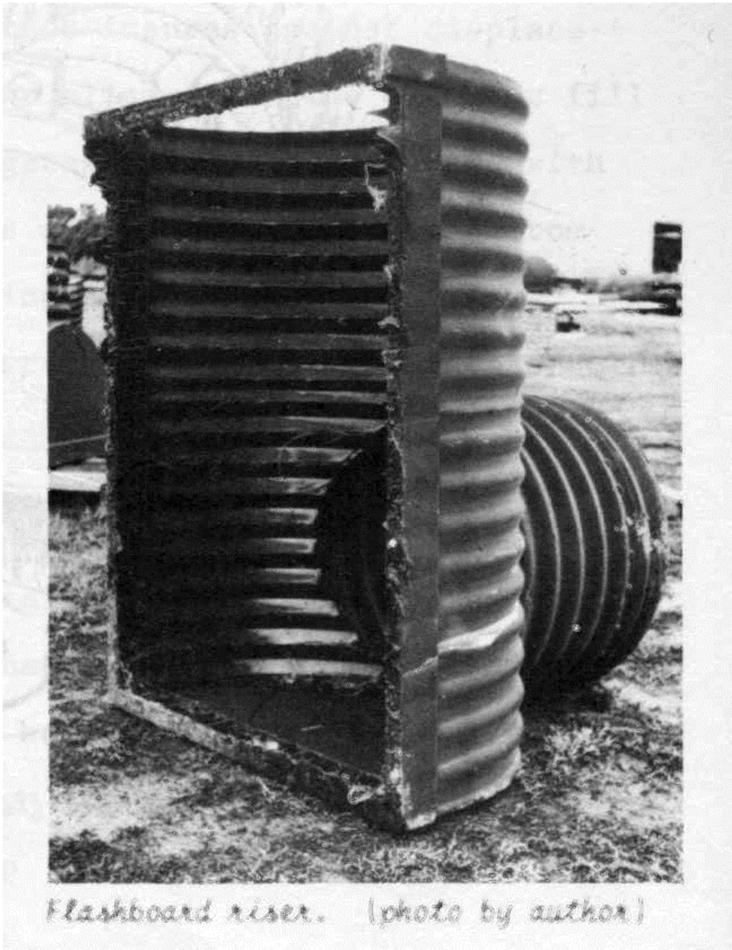


Figure A-9. Flashboard riser. Photo by G. Rollins (Rollins 1981).

Flashboard boxes or weir boxes are redwood boxes with side grooves for inserting wooden planks. The planks are placed one on top of the other to obtain the desired water height. They function in the same manner as flashboard risers, but on a smaller scale. Weir boxes are placed in interior levees to control the amount of water entering or draining from a pond or supply ditch.

All water control structures should be maintained in good working order, free of debris and silt. Leakage should be kept at the minimum practical and necessary repairs should be made promptly. Water passage capacities should be maintained at levels that will permit a 30-day flood and drain cycle to be achieved (SRCD 1980).   Plastic water control structures have a possible life expectancy of 20-30 years where steel is expected to last 8 to 12 years on average (DWR 2001). The average cost of replacing a water control gate is $15,000 (DWR 2001).

A-4 CONTROLLABLE TOPOGRAPHY

Wetland managers can encourage desired plant species in part by contouring and disturbing pond bottoms. Grading pond bottoms can control topography. The soil removed from pond bottoms can be used to create higher elevations in low pond areas or to create upland habitat such as resting islands. Changes in topography to create diverse pond bottom elevations can cause changes in plant communities. Desirable wetland plants readily invade disturbed soils from discing at the higher pond elevations such as dock, annual grasses, upland herbs, and brass buttons (Rollins 1981). Relatively level ponds with high elevations and good drainage produce quality stands of fat-hen (Rollins 1981). Alkali bulrush commonly occurs at lower pond elevations that are not level (Rollins 1981). Pickleweed, sea purslane, and lamb's quarter are other marsh plants commonly found at lower pond elevations (Rollins 1981). (Figure 6, page 28) Other more influential factors affecting plant community composition directly related to pond topography are length of time and depth of submergence as well as soil salinity.

Resting islands are areas of exposed pond bottom and short or mowed vegetation that allow wildlife a clear field of view for predators (SRCD 1998). Resting islands are created by grading the pond bottom to between 1" below water level to 6" above water level. These islands provide refuge for terrestrial species such as the salt marsh harvest mouse, shallow areas for shorebirds, and resting areas for waterfowl. Islands also provide nesting habitat for both mammals and birds.

A-5 PUMPS (Permanent/Portable)

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 dependant 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 DFG, U.S. Fish and Wildlife Service (USFWS) delta smelt, and National Marine Fisheries Service (NMFS) salmonid criteria are able to be used year-round (Biological Assessment 1999).

Permanent pumps are electrical, requiring costly electricity to run. The annual electrical costs for Grizzly Island Wildlife Area averages $37,000 (DFG 1988). These pumps are permanently enclosed in wooden pump houses suspended above a primary ditch on pilings adjacent to a water control structure. 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.

A-6 FISH SCREENS (Conical/Flat screen)

Screened water diversions assist in the protection of aquatic species such as winter and spring run salmonids and delta smelt while allowing managers to effectively manage wetlands. Screened water diversions allow managers to maintain diverse managed wetland habitats because managers are able to access water during critical germination periods and periods of fresher water (SRCD 1998).

Both fish screen types, conical and flat screen, are used in the Suisun Marsh. Fish screens are self-cleaning to comply with regulated approach velocities and minimize maintenance costs. The design of fish screens allows manual rising of the screens for removal, repair, and out-of-water storage during non-diversion periods to minimize corrosion. Due to the brackish environment, fish screens are constructed out of a corrosive resistant material with some coated with epoxy and cathodically isolated to decrease corrosion.

A-7 STRUCTURE MAINTENACE CONSTRAINTS

The major constraint posed by water control structures and their maintenance is cost. Water control structure maintenance and replacement can cost from hundreds to tens of thousands of dollars. Levees need to be periodically refurbished or cored, ditches need to be kept clear of obstructions such as debris and silt, and water control structures need to be kept in good working order. Pumps and fish screens also need periodic maintenance, cleaning, or replacement to insure efficient operation.

The other major constraint includes permitting requirements for maintenance and replacement of control structures through the Suisun Resource Conservation District's

U.S. Army Corps of Engineers (USACE) Regional General Maintenance Permit (RGP) for the primary management area of the Suisun Marsh. For any work not covered under the existing permit such as installing new floodgates or replacing riprap an individual permit must be filed with the USACE.

Appendix B

Plant Descriptions

B-1 PLANT DESCIPTIONS

A table outlining requirements, habitat values, and acreage of key plants in Suisun Marsh can be found on page 46.

B-1.1 Important Wetlands Plants

Fat hen (*Atriplex triangularis*): Native annual 30-90 cm high producing abundant seeds. Fat hen is found in salt and brackish coastal marshes (SRCD 1998) and managed ponds of intermediate elevation, slightly higher than brass buttons (Rollins 1981). It is often the first to invade bare areas. Fat hen survives best in soils submerged three to five months, three months being optimum (Burns 2003, SRCD 1998). Habitat managers can encourage fat hen growth by beginning drawdown of water in late January or February (SRCD 1998). Over half of the seedlings emerge by mid-February so inundation past this time period reduces new growth (Rollins 1981). Fat hen can tolerate salinity of between 13-49 parts per thousand total dissolved solids (ppt TDS) or 20-77 milliSiemens/cm (mS/cm) (DWR 2001), but optimum is between 30 mS/cm and 45 mS/cm (SRCD 1998).

Fat hen was originally thought to be of great importance as waterfowl food in Suisun, probably because earlier studies concentrated on gizzard samples of ducks shot by hunters early in the morning (Burns 2003). More recent evidence shows that fat hen is consumed nocturnally, but overall is eaten in proportion to its availability by pintails and avoided by green-winged teal and mallards (Burns 2003). There were 2,053 acres of fat hen in diked areas of Suisun Marsh in 2000 (DFG 2000).

Lamb's quarters, pigweed (*Chenopodium album*): Nonnative annual with leathery leaves 18-100+ cm tall. Lamb's quarters grows on pond bottoms and germinates later in the year than fat hen (SRCD 1998). Lamb's quarters tolerates salinities up to 62 mS/cm (SRCD 1998).

Brass buttons (*Cotula coronopifolia*): Nonnative perennial up to 50 cm high. Brass buttons germinates winter to spring and forms a thick fleshy yellow-flowered carpet. It is adaptable, invading disturbed soil, and may be found year-round in moist soil. Brass buttons is often found on the edges of shallow ponds still flooded in early spring and will continue to grow where soil salinity remains relatively high. Brass button grows best when given two to four months submergence (Rollins 1981). It tolerates salinities from 9-30 ppt TDS (14-48 mS/cm) (DWR 2001).

Originally thought to be of high importance as duck food, brass buttons is now thought to be less favored by green-winged teal and pintails and actually avoided by mallards (Burns 2003). In 2000, there were 416 acres dominated by brass buttons in Suisun diked areas (DFG 2000).

Swamp timothy (*Crypsis schoenoides*): Nonnative mat-like annual grass with stems 5-75 cm. Swamp timothy is uncommon in Suisun Marsh, growing under the freshest conditions (up to 5 mS/cm salinity). It is found in pond bottoms following late spring drainage. It is thought to be excellent food for northern pintails (SRCD 1998). In 2000, there were 74 acres of swamp timothy in Suisun diked areas (DFG 2000).

<u>Watergrass</u> (*Echinochloa crus-galli*): Nonnative annual grass 25-150 cm. high, producing large quantities of seed. Watergrass must be planted in late spring or early summer and have frequent irrigation (Rollins 1981). Subsequent year's watergrass may be a volunteer. It can grow in soils with salinities between 4-6 mS/cm (DWR 2001). Watergrass requires three to four irrigation cycles and must be flooded and drained within seven days during the summer to control mosquitoes (Rollins 1981). See H. Traditional Watergrass Management Schedule (page 34).

Rollins (1981) reported that watergrass seeds are eaten by most duck species, other birds, and rodents. Burns (2003) found that mallards strongly preferred watergrass and green-winged teal and pintails ate it in proportion to its availability. It is important food for mallards late in the season. Burns suggests that watergrass has increased in Suisun through selective management. Watergrass is often associated with smartweed in Suisun. In 2000, there were 1090 acres of smartweed mixed with watergrass in Suisun diked areas (DFG 2000).

<u>Smartweed</u> (*Polygonum* spp.): Native/nonnative annual or perennial shrub or vine often rooting at the nodes. Smartweed must be grown in moist soils and may even be floating. Management is similar to that established for watergrass (SRCD 1998). Smartweed is at risk for contracting a fungus known as "smut" which destroys the plants' seeds (SRCD 1998). Soil salinities where smartweed is found generally do not exceed 5 mS/cm (DWR 2001).

Smartweed is thought to be good waterfowl food (particularly for pintail). It is often associated with watergrass in Suisun. In 2000, there were 1090 acres of smartweed mixed with watergrass in Suisun diked areas (DFG 2000).

<u>Sago pondweed</u> (*Potamogeton pectinatus*): Native perennial (producing fleshy corms in winter) submerged aquatic plant up to 80 cm. Sago pondweed grows in permanently flooded brackish ponds and ditches, or where water is absent no more than three months at a time (SRCD 1998). It is often the first plant to establish in newly flooded areas. Water disturbance, from winds or carp (*Cyprinus carpio*) movement, can easily disrupt the delicate root system (SRCD 1998). Sago pondweed can tolerate water salinities of 9-12 ppt TDS (14.0-18.7 mS/cm) (DWR 2001).

Ducks feed on all parts of the plant (Rollins 1981) as well as on the high number of invertebrates the dense plant material supports (DWR 2001, SRCD 1998). Canvasback and swans eat the tubers, which are high in carbohydrates (DWR 2001). Carp also eat this plant, competing with waterfowl (Rollins 1981). In 2000, there were 32 acres of sago pondweed in Suisun diked areas (DFG 2000).

Wigeongrass (*Ruppia maritima*): Native perennial submerged aquatic plant found in permanently flooded brackish ponds and ditches, usually in water depths of two to four feet. Wigeongrass grows best with water salinities of 5-23 mS/cm, but the seeds can tolerate long periods of drought and extremely high water salinities (up to 390 mS/cm) (DWR 2001, SRCD 1998). Like sago pondweed, wigeongrass can be disrupted by excessive wave action from winds or carp. However, wigeongrass has been observed to form dense stands in flowing water (SRCD 1998).

Many species of ducks feed on seeds, foliage, and rootstocks (Rollins 1981), and on the high number of invertebrates they support (DWR 2001). Wigeongrass is not abundant in Suisun.

Pickleweed (*Salicornia virginica*): Native fleshy perennial or subshrub 20-70 cm. Pickleweed is found in poorly drained highly saline pond bottoms, flooded for a maximum of six months. If it becomes invasive, pickleweed can be controlled by cross-discing (preferable) or mowing close to the ground in August or September and flooding the pond for waterfowl season (Rollins 1981). When pickleweed becomes woody, it should be disced to allow new and more productive growth (SRCD 1998). A well-drained pond with ditches reaching to the lowest points combined with leaching cycles typically used to promote fat hen or alkali bulrush will generally not sustain a significant population of pickleweed (Rollins 1981). Pickleweed grows best in soils between 31-67 ppt TDS (48-105 mS/cm) salinity (DWR 2001).

Pickleweed is an important food plant for omnivorous waterfowl species such as wigeon, gadwall, and northern shovelers (SRCD 1998) because it provides nutrition from plant parts, seeds, and invertebrates that live among the branched stems and leaves (De Szalay and Resh 1996). In 2000, there were 12,380 acres of pickleweed in diked areas of Suisun Marsh (DFG 2000).

Tules (*Scirpus acutus* and *Scirpus californicus*): Native perennial emergents 150-400 cm. Tules are found in fresh or salt marshes (up to 17 mS/cm salinity), along sloughs, ditches, and in permanent ponds, usually in dense stands. Tules can grow in water up to four feet deep (Rollins 1981) and require at least nine months submergence (SRCD 1998). Tules reproduce mainly through underground vegetative rhizomes and infrequently through seed. Stands can break off and float in clumps to establish elsewhere, sometimes blocking drainage structures. It is recommended that tules not dominate more than 30% of the surface area of permanent ponds (Rollins 1981). Large stands may disrupt flight patterns of waterfowl. Tules can be controlled by mowing close to the ground in August or September and flooding at least one foot over the tops of the stubble from October to May. Prior to flooding, the stubble and litter may be burned if feasible. Managers wishing to limit tules should follow leaching schedules to promote fat hen or alkali bulrush. Control of tules may take longer than controlling cattails. In 2000, there were 2389 acres of *Scirpus americanus*, *S .californicus,* or *S. acutus* in Suisun diked areas (DFG 2000).

Alkali bulrush (*Scirpus maritimus*): Native perennial 80-150 cm high. Alkali bulrush is found in coastal brackish and salt marshes and in inland alkali and brackish marshes (Hotchkiss 1972). It is not dominant in historic tidal wetlands of eastern Suisun Marsh and is subdominant to codominant near the southwestern reach of Suisun Marsh (DWR 2001). Alkali bulrush reproduces primarily by clonal vegetative growth through extensive underground rhizomes, but can propagate by seed during periods of low salinity (high precipitation) (Burns 2003). Seeds float for several days before sinking and will survive long dormancy periods while waiting for favorable conditions (Lieffers and Shay 1981). Alkali bulrush should have seven to eight months of submergence each growing season (Rollins 1981). If less than six months is allowed, pickleweed and saltgrass may dominate. Submergence greater than nine months encourages cattails and tules (SRCD 1998).

Alkali bulrush germination occurs at salinities from 11-22 mS/cm, with none occurring at salinities above 35 mS/cm. Once the plant is established, it can tolerate salinity up to 42 mS/cm (SRCD 1998). Alkali bulrush can tolerate extremely saline conditions for up to three years, albeit with a temporary reduction in seed production (Rollins 1981).

Alkali bulrush is the primary food plant encouraged by waterfowl habitat managers. (See G. Traditional Alkali Bulrush / Intermediate Hydroperiod water (page 33). The original salinity objectives for the Suisun Marsh addressed in the 1978 State Water Resources Control Board's (SWRCB) Decision 1485 (D-1485) were based on the requirements of alkali bulrush (SWRCB 2000). The SWRCB's decision was driven by research by Mall and Rollins (Mall 1969 and Rollins 1973) identifying applied water salinity requirements for alkali bulrush and the accepted value at the time of alkali bulrush as waterfowl food. Since that time, new research has shown that pintails and mallards consume alkali bulrush only in proportion to its availability (Burns 2003). It is still, however, considered an important food source and is easily grown in managed areas of Suisun. Management favoring alkali bulrush also favors fat hen and brass buttons and inhibits pickleweed, tule, cattail, and saltgrass growth (Rollins 1981). In 2000, there were 2,478 acres of alkali bulrush in diked areas of Suisun Marsh (DFG 2000).

Sea Purslane (*Sesuvium verrucosum*): Native fleshy perennial up to 90 cm. Sea purslane grows in moist or seasonally dry flats and margins of saline wetlands. Seeds are 0.1-1 mm. and smooth. Sea purslane decomposes rapidly when submerged (SRCD 1998). Few landowners actively manage for sea purslane although it is known to occur in the lowest pond bottoms with high saline soil and is generally available early in the season as ducks return to the Marsh (Burns 2003). Sea purslane tolerates high salinities up to 100 mS/cm (SRCD 1998).

Previous studies showed this plant to have little importance as waterfowl food. However, Burns (2003) showed that pintails and green-winged teal actively select this plant when feeding while mallards eat it in proportion to its availability. In 2000, there were 573 acres dominated by sea purslane in Suisun diked areas (DFG 2000).

Cattail (*Typha* sp.): Native perennial emergent 150-300 cm. Cattails are usually found along banks of sloughs and ditches and in permanently flooded ponds or any area receiving greater than nine months submergence. They are found in fresher areas of the Marsh (up to 15 mS/cm salinity), in the eastern half or wherever freshwater is present from underground aquifers or seeps (Rollins 1981). If conditions are favorable, cattails can be easily established by planting divisions (SRCD 1998).

Cattails can impede water flow by building up around gates or blocking ditches. Large stands may disrupt flight patterns of waterfowl (SRCD 1998). If they become a problem, mowing close to the ground in August or September and flooding at least one foot over the tops of the stubble from October to May can control them. Prior to flooding, the stubble and litter may be burned if feasible. Other mechanical methods include cutting, crushing, and discing when the pistillate spikes are a lime green color (SRCD 1998). Optimally, discing should be done three times per year, in fall, spring and summer. Managers wishing to limit cattails should follow leaching schedules to promote fat hen or alkali bulrush and be sure to drain quickly to prevent cattail seedlings from establishing on mudflats. Ditches should be dredged to a minimum of three feet. Ponds that have subsided to elevations prohibiting gravity drainage are particularly problematic. In these cases, systemic herbicides, such as Roundup® or Aquamaster™ (both glyphosate) may be applied in June or July when seed heads are maturing. The dead plant material can then be mowed or burned prior to fall flooding.

Cattails provide food and cover for wildlife. In 2000, there were 4955 acres of cattails in Suisun diked areas (DFG 2000).

B-1.2 Important Upland Plants

In 2000, there were 6361 acres of annual grasses or annual grasses mixed with weeds in Suisun diked areas (DFG 2000).

Quail brush/ Big saltbush (*Atriplex lentiformis*): Native shrub 80-300 cm in height and more wide than tall. Quail brush is found on levee tops and upland fields. It may become somewhat dormant in winter. Quail brush provides cover and nesting sites for upland species, including passerines (SRCD 1998). In pheasant habitat, edge cover, made up of saltbush and tall wheatgrass (*Elytrigia elongata*), provides cover from predators, dogs, and hunters. Saltbush provides mass while tall wheatgrass provides a vertical edge. This species rarely needs to be controlled, but it can be burned or bulldozed if it becomes a nuisance. In 2000, there were 26 acres of big saltbush in Suisun diked areas (DFG 2000).

Wild oat (*Avena fatua*): Nonnative annual grass 30-120 cm tall. Wild oat is easily established in disturbed fields. It may need occasional mowing, burning, or discing to renew growth. This grass provides good cover for wildlife and food for ungulates (SRCD 1998).

Coyote brush (*Baccharis pilularis consanguinea*): Native woody shrub up to 200 cm high and 250 cm wide. Coyote brush is common in upland fields and levee tops. It provides cover and nesting sites for upland species, including passerines (SRCD 1998). Coyote brush can become impenetrable over time on little used levee trails. It can be burned, bulldozed, or cut back if it becomes a nuisance. In 2000, there were 92 acres of coyote brush in Suisun diked areas (DFG 2000).

Wild mustard (*Brassica* spp.): Nonnative annual 20-100 cm. Mustard is most often found in disturbed places, such as levee tops and roadsides. It is good cover for breeding waterfowl and other wildlife, such as short-eared owls, northern harriers, and ring-necked pheasants.

Brome (*Bromus* spp.): Native or nonnative annual grass 10-40 cm tall. Brome is easily established in disturbed fields. It may need occasional mowing, burning, or discing to renew growth. This grass provides good cover for wildlife and food for ungulates (SRCD 1998). In 2000, there were 8 acres of bromes in Suisun diked areas (DFG 2000).

Tall wheatgrass (*Elytrigia elongata*): Nonnative perennial grass growing from rhizomes 35-130 cm tall. Tall wheatgrass is easily established in disturbed fields. It may need occasional mowing, burning, or discing to renew growth. Tall wheatgrass is important for food and cover for ungulates and upland game (SRCD 1998). In pheasant habitat, edge cover, made up of saltbush and tall wheatgrass, provides cover from predators, dogs, and hunters. Saltbush provides mass while tall wheatgrass provides a vertical edge. In 2000, there were 86 acres of tall wheatgrass in Suisun diked areas (DFG 2000).

Barley (*Hordeum* spp.): Domesticated annual grass 10-50 cm tall. Barley requires precipitation for growth because channel water is too saline (DWR 2001). Barley may be actively cultivated, but when established it grows well and may even become invasive (SRCD 1998). It is prone to depredation by starlings and blackbirds (Rollins 1981). Barley requires occasional mowing, burning, or discing to renew growth. Ducks eat barley seeds in September and early October before duck clubs flood for the hunting season. Geese feed on the seeds and young plants in winter (Rollins 1981). This grass also provides good cover for wildlife and food for ungulates (SRCD 1998). In 2000, there were 2 acres of barley in Suisun diked areas (DFG 2000).

Italian rye grass (*Lolium multiflorum*): Nonnative annual or biennial grass 90-150 cm tall. Italian rye grass is easily established in disturbed fields. It may need occasional burning and mowing (SRCD 1998). Italian rye grass provides food for waterfowl and is important as nesting cover for waterfowl and other ground-nesting birds, such as short-eared owls, northern harriers, and ring-necked pheasants (SRCD 1998). In 2000, there were 264 acres of rye grass in Suisun diked areas (DFG 2000).

Harding grass (*Phalaris* spp.): Nonnative perennial grass 60-150 cm high. Harding grass is easily established in disturbed fields. It may need occasional mowing, burning, or discing to renew growth. Waterfowl use Harding grass for nesting and escape cover.

Harding grass is important food and cover for ungulates and upland game (SRCD 1998). In 2000, there were 22 acres of Harding grass in Suisun diked areas (DFG 2000).

Rabbit's foot grass (*Polypogon monspeliensis*): Nonnative annual grass 20-100 cm tall. This common grass is able to grow in highly disturbed seasonally or permanently saturated soils subject to brackish or saline conditions (SRCD 1998). Rabbit's foot grass can be used as food and cover for waterfowl (SRCD 1998). In 2000, there were 54 acres of rabbitsfoot grass in Suisun diked areas (DFG 2000).

Wild radish (*Raphanus sativus*): Nonnative annual 40-120 cm high. Radish is found in disturbed places in uplands, roadsides, and levee tops. Radish is good cover for breeding waterfowl and other ground-nesting birds, such as short-eared owls, northern harriers, and ring-necked pheasants.

California rose (*Rosa californica*): Native shrub 80-250 cm high, forming dense thickets. Rose grows along levees and roadsides where the ground is moist. Rose is excellent at stabilizing slough banks. If it becomes invasive, especially on levees, it can be mowed or sprayed with Garlon (triclopyr). Rose provides cover and food for wildlife, including passerines.

Blackberry (*Rubus* spp.): Native or nonnative woody perennial forming brambles and producing dark reddish fruits. Blackberry grows along levees, roadsides and stream banks in moist soil (SRCD 1998). It is excellent at stabilizing slough banks. Blackberry provides cover and food for wildlife, including passerines. The nonnative Himalayan blackberry (*Rubus discolor*) is on the 1999 California Invasive Plant Council's (Cal-IPC) List A-1: most invasive wildland pest plants; widespread. All blackberry species can be controlled by mowing back or spraying with Garlon (triclopyr). In 2000, there were 54 acres of blackberry in Suisun diked areas (DFG 2000).

Curly dock (*Rumex crispus*): Nonnative erect perennial less than 150 cm tall. Curly dock is common in many different types of habitat, including wet or moist meadows, flats, and shallow fresh or brackish marshes (SRCD 1998). It provides little wildlife value, but is generally not actively controlled. In 2000, there were 16 acres of curly dock in Suisun diked areas (DFG 2000).

Vetch (*Vicia* spp.): Nonnative vine-like annual or biennial. Vetch can be planted by first discing the ground, them mixing the seeds with a nitrogen fixer, followed by drilling the seeds into the ground at least one-quarter inch (SRCD 1998). The seeds are sown in September or October and germinate late in the fall. Vetch will mature in late May. Vetch provides important cover for breeding waterfowl and other ground-nesting birds, such as short-eared owls, northern harriers, and ring-necked pheasants.

B-1.3 Plants to Control

Giant Cane (*Arundo donax*): Nonnative perennial grass to 8 m. This plant is on the 1999 California Invasive Plant Council's (Cal-IPC) List A-1: most invasive wildland pest plants; widespread. Most of the giant cane in managed marshes of Suisun has been planted by landowners for windbreaks or privacy. Once established, it spreads through rhizomes along roadsides and banks. Giant cane displaces native plants, including rare plants found along the water's edge such as Suisun Marsh aster (*Aster lentus*), Delta tule pea (*Lathyrus jepsonii*), and Mason's lilaeopsis (*Lilaeopsis masonii*) (CNDDB 2003). Giant cane is highly flammable, provides little value for wildlife, and creates erosion and flooding problems (DFG 2001). Seedlings of this plant should be hand pulled as soon as possible. Older plants can be chopped, cut, mowed, or burned for several consecutive years. Burning or cutting can also be followed by an herbicide application with Roundup Pro®. To be even more effective, the area should be followed by either a second burn later in the year or revegetation with native plants (SRCD 1998). In 2000, there were 2 acres of giant cane in Suisun diked areas (DFG 2000).

White-top (*Carderia pubescens*): Nonnative perennial 10-40 cm. This plant is on the California Department of Food and Agriculture's (CDFA) Noxious Weed List B. White-top displaces native plant species and agricultural crops (DFG 2001). White-top is found on saline soils in fields and along ditch banks (SRCD 1998). As with perennial pepperweed, this plant is best controlled by the herbicide Telar® (chlorsulfuron), which attacks only broadleaf plants and not grasses. Telar® should be applied as a pre-emergent or early post-emergent spray when weeds are actively germinating or growing. Glyphosate (Roundup®) may also be used but will kill all treated plants.

Poison hemlock (*Conium maculatum*): Nonnative biennial 50-300 cm tall with purple spots on the stems. This plant is on the 1999 Cal-IPC List B: wildland pest plants of lesser invasiveness. Poison hemlock can be fatal to humans and other animals if eaten. This plant is common in disturbed moist areas, such as roadsides and levee tops. It can be controlled by applying glyphosate (Roundup® or Aquamaster™). In 2000, there were 290 acres of poison hemlock in Suisun diked areas (DFG 2000).

Pampas grass (*Cortaderia selloana*): Nonnative perennial grass 200-400 cm. Pampas grass has large silky flower heads that disperse seeds during strong winds to invade new areas. This plant is on the 1999 Cal-IPC List A-1: most invasive wildland pest plants; widespread. It grows in cleared upland areas or alongside water edges, such as near drains, displacing native plant species including the rare Mason's lilaeopsis (CNDDB 2003, DFG 2001). Pampas grass can be controlled with glyphosates (Roundup® or Aquamaster™), Hexazinone (Velpar LR®), and grass selective herbicides such as Verdict R®, Sertin R®, and Fusilade R®. Pampas grass can also be manually or mechanically removed; however, the rootstock must be dug up and removed as well to prevent resprouting (SRCD pers. comm.). In 2000, there were 6 acres of pampas grass in Suisun diked areas (DFG 2000).

Saltgrass (*Distichlis spicata*): Native perennial grass 10-50 cm. In managed marshes, saltgrass can become problematic by forming dense impenetrable mats over time in saline uplands flooded less than four months per year. Burning followed by discing is the easiest way to control this plant (Rollins 1981). Where burning is undesirable, deep flooding for six or more weeks can cause mats to die back, break apart and float to the surface. However, flooding for long periods can produce heavy mosquito infestations (SRCD 1998). In 2000, there were 9569 acres of saltgrass or saltgrass associations in Suisun diked areas (DFG 2000).

Fennel / anise (*Foeniculum vulgare*): Nonnative tap-rooted perennial 90-200 cm. Fennel is on the 1999 Cal-IPC List A-1: most invasive wildland pest plants; widespread. This plant is common in disturbed moist areas, such as roadsides and levee tops. Fennel can be mowed to improve visibility on roadsides and levees. In 2000, there were 81 acres of fennel in Suisun diked areas (DFG 2000).

Baltic rush (*Juncus balticus*): Native perennial 35-110 cm. This plant can form dense stands at higher elevations in well-drained soils in managed marshes (Rollins 1981). It can be problematic near levee leaks and aquifers. Baltic rush does not provide significant amounts of food for waterfowl (Rollins 1981). It is difficult to control because it does not burn or mow well, and cannot be disced unless plowed first (Rollins 1981). Small or sparse stands can be repeatedly cross-disced in late summer and fall and flooded late into the spring, or mowed and deep flooded. Large or growing stands must be mowed and plowed until plants are uprooted. Sometimes only a ripper bar dragged behind a tractor can penetrate the heavy thatch (Rollins 1981). In the fall, the resulting litter can be burned. Glyphosate (Roundup® or Aquamaster™) can also be used effectively to control Baltic rush. In 2000, there were 1091 acres of Baltic rush in Suisun diked areas (DFG 2000).

Perennial Pepperweed (*Lepidium latifolium*): Nonnative perennial 40-200 cm tall. Perennial pepperweed is one of the most problematic nonnatives in Suisun Marsh. It is on the 1999 Cal-IPC List A-1: most invasive wildland pest plants; widespread and on the CDFA Noxious Weed List B. Pepperweed invades both upland and wetland areas, including tidal zones where spraying is generally not permitted. It spreads mainly by rhizomes and populations can double or triple in very short periods of time. Pepperweed displaces native plants, including rare plants such as Suisun Marsh aster, Delta tule pea, and Mason’s lilaeopsis (CNDDB 2003).

SRCD has reported limited success using Roundup® (glyphosate) to control pepperweed populations. In spring to early summer, plants are mowed, sprayed, disced, and then sprayed again. Discing is recommended only after spraying. In upland areas, this plant is best controlled by the herbicide Telar® (chlorsulfuron), which attacks only broadleaf plants and not grasses. Telar® should be applied as a pre-emergent or early post-emergent spray when weeds are actively germinating or growing. In 2000, there were 682 acres of perennial pepperweed in Suisun diked areas (DFG 2000).

Phragmites/common reed (*Phragmites australis*): Native/nonnative perennial 200-400 cm tall forming dense stands. *Phragmites* can be native (uncommon in Suisun Marsh and noninvasive) or nonnative. The invasive *Phragmites* (“haplotype M”), strongly believed to be a nonnative form indigenous to Eurasia, can aggressively invade wetlands (Saltonstall 2002). This type of invasion is known as “cryptic”, since the invasive type can be easily mistaken for native type. *Phragmites* generally spreads by creeping rhizomes or by root masses breaking free and floating to establish in new areas. It also reproduces by seed carried on the wind. Dense stands of *Phragmites* have been known to shade and eventually kill the rare plant Mason's lilaeopsis (CNDDB 2003).

Phragmites can be controlled with Roundup® or Aquamaster™ (both glyphosate). 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. Prior to herbicide application, the pond should be drained, preferably two to four weeks before 10% to 20% of the stand is in bloom, causing the plants to become stressed. Mechanical options include mowing, deep discing, bulldozing, crushing, flooding, draining, and burning (SRCD 1998). In 2000, there were 479 acres of *Phragmites* in Suisun diked areas (DFG 2000).

Cocklebur (*Xanthium strumarium*): Nonnative annual to 150 cm. Cocklebur displaces other more desirable plants and is difficult to control once established because of the large numbers of seeds added to the seed bank. Cocklebur can be mowed, flooded, or a combination of the two. Young plants can be flooded one to two weeks. Mowing should be accomplished before the plants flower and immediately flooded for 10 to 14 days. Herbicides, such as Roundup Pro® (glyphosate), can be applied before the fruits appear (SRCD 1998). In 2000, there were 1090 acres of cocklebur mixed with smartweed and watergrass, and 10 acres mixed with Phragmites in Suisun diked areas (DFG 2000).

B-1.4 Endangered, Threatened and Rare Plants

Though diked marshes typically lack rare plants (Goals Project 2000), these areas may approximate aspects of vernal pools, alkali basins, or upper tidal marsh transition areas. In fact, there are known populations of rare plants within diked marshes or on the outboard sides of levees surrounding diked marshes (CNDDB 2003, DWR 1999, Goals Project 2000). The following eight rare plants are known to occur on diked marshes of Suisun.

Suisun Marsh aster (*Aster lentus*): Suisun Marsh aster is listed in Category 1B on the California Native Plant Society's (CNPS) list of rare, threatened, or endangered plants in California and elsewhere (CNPS 2003). Historically, this plant was found at mid- to high-tide levels along tidal streams and marshes of the lower Sacramento-San Joaquin Delta, the Suisun Marsh, and the northern reaches of the San Francisco Bay (CALFED 1999). Currently, it is found along tidally influenced shores and some non-tidally influenced ditches and interior levees in the Sacramento-San Joaquin Delta (Sacramento and San Joaquin Counties), Suisun Marsh (Solano, and Contra Costa Counties), and marshes associated with the Napa River north of San Pablo Bay (Napa County)(CNDDB 2003, CNPS 2003). Most reported populations are less than one-hundred plants, with some occurrences numbering in the hundreds (CNDDB 2003).

Suisun Marsh aster occurs along riverbanks, tidal slough edges, and the outboard side of levees subject to tidal influence (DWR 1999). Diked wetlands that retain water throughout the year in these regions may support Suisun Marsh aster (DWR 1999). Suisun Marsh aster is associated with the rare plants Mason's lilaeopsis (*Lilaeopsis masonii*) and Delta tule pea (*Lathyrus jepsonii*) (CNDDB 2003).

Suisun Marsh aster is threatened by marsh alteration and loss, trampling by livestock, damage by angler or hunter foot traffic, recreational watercraft induced waves, levee repair and maintenance, replacement or installation of tide gates, competition from non-native plants, herbicide use, and mowing (CNDDB 2003, CNPS 2003, DWR 1999).

Presence of Suisun Marsh aster in Suisun: Detailed surveys of Suisun Marsh aster were conducted by the Departments of Water Resources (DWR) and Fish and Game (DFG) in 1991, 1992, and 1993 for the Western Suisun Marsh Salinity Control Project and in 1992 as part of the biological assessment for the State Water Resources Control Board. Those and other findings show Suisun Marsh aster to occur along the tidal edges and levee bottoms in all major sloughs of Suisun Marsh (CNDDB 2003). This species can also be found on levee crowns, riprap-covered levees, and distribution and drainage ditches of diked wetlands (CNDDB 2003, DWR 1999).

Presence of Suisun Marsh aster in diked wetlands of Suisun: Suisun Marsh aster occurs along inside channel banks at the Morrow Island Distribution System and other distribution ditch banks (DWR 1999). It is also present throughout the Marsh on or adjacent to levees between diked wetlands and tidal areas mainly, but not always, on the outboard side (CNDDB 2003).

Measures currently taken to preserve species: Surveys for this plant, which should be done in October when it is in bloom, are not regularly conducted (DWR 1999). Replacement or installation of tide gates, levee maintenance, and fish screen installation could potentially harm this species in Suisun Marsh (DWR 1999).

<u>Alkali milkvetch (*Astragalus tener* var. *tener*):</u> Alkali milk-vetch is listed in Category 1B on the CNPS's list of rare, threatened, or endangered plants in California and elsewhere (CNPS 2003). Historically, this plant was found from the San Francisco Bay south to the Central Coast, and inland from Yolo County to the San Joaquin Valley (DWR 1999). Today, it is known from populations in Yolo, Solano, Alameda, Merced, and possibly Napa Counties (CNDDB 2003, DWR 1999). Most reported occurrences number between 20 and several hundred plants, with some populations numbering in the thousands (CNDDB 2003).

This plant can be locally abundant in seasonally moist areas, especially at the margins of vernal pools and alkali scalds and flats, in alkaline playa lakes or inundated, claypan, vernal playa-type pools, and in valley and foothill grasslands (CNPS 2003, DWR 1999). It is associated with other rare vernal pool plants, such as valley spearscale (*Atriplex joaquiniana*), Contra Costa goldfields (*Lasthenia conjugens*), and legenere (*Legenere limosa*) (CNDDB 2003, DWR 1999).

Alkali milk-vetch is threatened by habitat destruction, especially agricultural conversion, heavy grazing by sheep and cattle, discing and mowing for fire control, permanent flooding for waterfowl, and competition from exotic plants, such as perennial pepperweed (*Lepidium latifolium*) (CALFED 1999, CNPS 2003, DWR 1999).

Presence of alkali milk-vetch in Suisun: This plant has been documented in four locations in Suisun Marsh: at the Montezuma Wetlands Restoration project on the eastern side of the Marsh, just south of State Highway 12 near the terminus of Hill Slough and the Potrero Hills Landfill, on private land slightly southeast of the Hill Slough/landfill site near Scally Road, and on private land on the northeastern edge of the Marsh near Ledgewood Creek (CNDDB 2003, DWR 1999). Additionally, there are a number of playa lake vernal pools and moist grasslands at the northeast base of the Potrero Hills between Hill Slough and Union Creek, near Luco Slough and Denverton Creek, and on the east side of the Marsh from Denverton to Montezuma that have not been fully explored and may support this species.

Presence of alkali milk-vetch in diked wetlands of Suisun: All four areas where alkali milk-vetch has been observed are in diked wetlands or in areas not receiving any tidal influence, and there is a possibility that other unexplored private lands may support Alkali milk-vetch as well (CNDDB 2003, DWR 1999). Poorly drained alkali scalds occur within diked wetlands in Suisun Marsh and these areas support plants commonly associated with alkali milk-vetch.

Measures currently taken to preserve species: In Suisun, there are no measures being taken to survey for or preserve alkali milk-vetch. However, one concern is that any management changes in flooding and draining could negatively impact some populations of alkali milk-vetch if present (DWR 1999). Other concerns include grazing, urban development, and landfill expansion (DWR 1999).

<u>Heartscale (Atriplex cordulata):</u> Heartscale is listed in Category 1B on the CNPS's list of rare, threatened, or endangered plants in California and elsewhere (CNPS 2003). Heartscale is endemic to the Sacramento and San Joaquin Valleys, and the San Francisco Estuary (CNDDB 2003, DWR 1999). Today, it can be found in Glenn, Butte, Tulare, possibly Alameda, Solano, Merced, Fresno, Madera, and Kern Counties (CNDDB 2003). Recently reported populations range from 10 to 10,000 plants (CNDDB 2003).

Heartscale lives in alkaline or saline chenopod scrub, desert scrub, alkali scalds, and sandy grassland habitats (CALFED 1999, DWR 1999). It can occur with other rare plants such as brittlescale (*Atriplex depressa*) and valley spearscale (CNDDB 2003).

Historically, heartscale habitat has been lost to agricultural and urban land conversions (CALFED 1999). Currently, threats include agriculture, grazing by goats, and highway and aqueduct rights-of-way maintenance (CNDDB 2003).

Presence of heartscale in Suisun: In the mid-1990s a single plant was found on the outboard side of a Montezuma Slough levee near the Suisun Marsh Salinity Control

Gates (DWR 1999). There are no other known populations of heartscale within the boundaries of Suisun Marsh, but populations are known to exist very near the Marsh, including one numbering in the hundreds near Collinsville to the east (CNDDB 2003, DWR 1999).

Presence of heartscale in diked wetlands of Suisun: In addition to the individual found on a levee, other plants may exist within managed wetlands, uplands, and levees in other areas of Suisun Marsh (DWR 1999). Marsh-wide surveys for this plant have not been conducted.

Measures currently taken to preserve species: There are no measures being taken to survey for or preserve heartscale in Suisun Marsh. If present, it could be affected by levee maintenance, installation and maintenance of tide gates, discing, burning, and herbicide use (DWR 1999).

<u>Brittlescale (*Atriplex depressa*):</u> Brittlescale is listed in Category 1B on the CNPS's list of rare, threatened, or endangered plants in California and elsewhere (CNPS 2003). Historically, it occurred throughout the lower Sacramento Valley to the San Joaquin Valley and the San Francisco Bay and Delta (CALFED 1999, DWR 1999). Today, it occurs in Butte, Colusa, Glenn, Yolo, Contra Costa, Alameda, Solano, Fresno, Merced, Madera, Kern and Tulare Counties (CNDDB 2003, DWR 1999). Populations number from ten to up to 30,000 individuals (CNDDB 2003).

Brittlescale is found in alkaline or clay soils of chenopod scrub, playas, vernal pools, meadows, and valley and foothill grassland communities. It is usually associated with alkali scalds and is generally found in drier areas than are other vernal pool plants (CALFED 1999, DWR 1999). Brittlescale has been found with other rare species such as alkali milk-vetch, heartscale and valley spearscale (CNDDB 2003).

Brittlescale is threatened by grazing by cattle or horses, trampling, sand mining, waterfowl club operations, loss of habitat from conversion to agriculture or urban development, invasion by exotic species such as perennial pepperweed, and herbicide use (CALFED 1999, CNDDB 2003, CNPS 2003).

Presence of brittlescale in Suisun: There are two known populations of several hundred plants each in Suisun Marsh: to the northeast just south of State Highway 12 near the terminus of Hill Slough and the Potrero Hills Landfill, and on the eastern side just north of the Montezuma Wetlands Project in a diked seasonal wetland of a private duck club (CNDDB 2003, DWR 1999).

Presence of brittlescale in diked wetlands of Suisun: The site near the Montezuma Wetlands Project site is in a diked private pond used for waterfowl hunting. The site near the terminus of Hill Slough is best described as muted tidal with very little tidal influence. Marsh-wide surveys have not been conducted for this plant.

Measures currently taken to preserve species: There are no measures being taken to survey for or preserve brittlescale in Suisun Marsh. Routine maintenance activities, such as flooding and draining of ponds, discing, burning, herbicide application, and fence construction may negatively affect brittlescale in Suisun Marsh (DWR 1999).

Valley spearscale (*Atriplex joaquiniana*): Valley spearscale is listed in Category 1B on the CNPS's list of rare, threatened, or endangered plants in California and elsewhere (CNPS 2003). Historically, valley spearscale is known to occur from southern Sacramento Valley to San Joaquin Valley, Suisun Marsh, and the San Francisco Estuary (DWR 1999). Today, valley spearscale can be found in Contra Costa, Yolo, Alameda, Solano, Napa, San Benito, Glenn and Colusa Counties (CNDDB 2003, DWR 1999). Most occurrences have populations numbering in the hundreds to thousands, with one up to 60,000 individuals (CNDDB 2003).

Valley spearscale grows in claypan vernal pools, alkali grasslands and meadows, alkali desert scrub, chenopod scrub, in alkali playas adjacent to tidal marsh and within diked seasonal wetlands (CALFED 1999, CNDDB 2003, DWR 1999). Valley spearscale is sometimes associated with other rare plants, such as alkali milk-vetch, heartscale, brittlescale, and Contra Costa goldfields (CNDDB 2003, DWR 1999).

Valley spearscale is threatened by grazing by cattle and horses, plowing and discing, other agricultural activities, erosion, fluctuating water levels, road and levee maintenance, invasion by exotic plants such as perennial pepperweed, possible landfill expansion, and urban development (CALFED 1999, CNDDB 2003, CNPS 2003)

Presence of valley spearscale in Suisun: There are four known populations of between a few individual plants and 200 plants each in Suisun Marsh: two to the northeast just south of State Highway 12 near the terminus of Hill Slough and the Potrero Hills Landfill, one small population on the northwestern edge of the Marsh on private property, and one on the eastern side of the Marsh in the Montezuma Wetlands Project (CNDDB 2003, DWR 1999).

Presence of valley spearscale in diked wetlands of Suisun: One of the sites near the terminus of Hill Slough is best described as muted tidal with very little tidal influence. The other site is in grassland just northeast of the first site. Both of the other two populations are in diked wetlands (CNDDB 2003, DWR 1999, SFEI 1999). Marsh-wide surveys have not been conducted for this plant and it may occur in other diked seasonal wetlands within the Suisun Marsh (DWR 1999).

Measures currently taken to preserve species: There are no measures being taken to survey for or preserve valley spearscale in Suisun Marsh. Routine maintenance activities, such as flooding and draining of ponds, discing, burning, herbicide application, and fence construction may negatively affect brittlescale in Suisun Marsh (DWR 1999).

Contra Costa goldfields (*Lasthenia conjugens*): Contra Costa goldfields is listed as endangered by the US Fish and Wildlife Service (USFWS), and in Category 1B on the

CNPS's list of rare, threatened, or endangered plants in California and elsewhere (CNPS 2003). Historically, it was found in Napa, Marin, Solano, Contra Costa, Alameda, Monterey, Santa Clara, Mendocino, and Santa Barbara Counties. Today, it has been extirpated from Santa Clara, Mendocino, and Santa Barbara Counties (CALFED 1999, CNDDB 2003, SRCD 1998). 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). In the past, this species may have also occurred in coastal prairies (CALFED 1999)**.** Contra Costa goldfields can occur with other rare plants such as Alkali milk-vetch and legenere (CNDDB 2003).

Contra Costa goldfields is threatened by urban development, conversion to vineyards, agriculture, horse and cattle grazing, encroachment by non-native plants including *Lolium multiflorum*, mountain bikes, and off-road vehicles, and addition of fill. In Suisun specifically, Contra Costa goldfields is threatened by discing, grazing, industrial development, and nonnative invasive plants (CALFED 1999, CNDDB 2003, CNPS 2003).

Presence of Contra Costa goldfields in Suisun: 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).

Presence of Contra Costa goldfields in diked wetlands of Suisun: The site near the terminus of Hill Slough is best described as muted tidal with very little tidal influence. The land on the extreme northwestern edge and areas near Scally Road are probably neither diked nor tidally influenced (SFEI 1999). The population near Ledgewood Creek is within diked lands and numbers in the thousands (CNDDB 2003).

Measures currently taken to preserve species: A recovery plan has not been prepared and recovery requirements have not been identified for this species (CALFED 1999). Suisun Resource Conservation District (SRCD) recommends that the landowner of property containing Contra Costa goldfields keep the area undisturbed and notify SRCD upon finding the species (SRCD 1998)

Delta tule pea (*Lathyrus jepsonii*): Delta tule pea is listed in Category 1B on the CNPS's list of rare, threatened, or endangered plants in California and elsewhere (CNPS 2003). Historically, this plant occurred on in-channel islands of the lower Sacramento and San Joaquin Rivers, Suisun Bay and Marsh, Napa River marshes, South San Francisco Bay, and in San Benito and Fresno Counties (DWR 1999). Today, it is present in most of the same regions, but populations have been fragmented by levee riprap (DWR 1999). Population sizes are often expressed in area rather than numbers due to the difficulty in determining individual plants that are intertwined. Colonies are made up of groups of plants that have formed masses along slough edges. Though most colonies today are small, one slough may have up to 100 colonies of Delta tule pea and a single colony might extend for up to one linear mile (CNDDB 2003, CNPS 2003, DWR 1999).

Delta tule pea occurs along riverbanks, tidal slough edges, and the outboard side of levees subject to tidal influence (DWR 1999). In Suisun 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, CNPS 2003, DWR 1999).

Presence of Delta tule pea in Suisun: A marsh-wide survey conducted in 1992 as part of the biological assessment for the State Water Resources Control Board found Delta tule pea throughout Suisun Marsh along parts of most sloughs and on the edges of islands in Suisun Bay (DWR 1999). Cordelia Slough contained the most colonies (94).

Presence of Delta tule pea in diked wetlands of Suisun: Delta tule pea is found on the outboard side of levees throughout Suisun Marsh where there is no riprap or other extensive disturbances (DWR 1999).

Measures currently taken to preserve species: SRCD recommends that the landowner of property containing Delta tule pea keep the area undisturbed and notify SRCD upon finding the species (SRCD 1998). Surveys, ideally conducted May–June, are not regularly conducted. Replacement or installation of tide gates, levee maintenance, and fish screen installation could potentially harm this species in Suisun Marsh (DWR 1999).

Mason's lilaeopsis (*Lilaeopsis masonii*): Mason's lilaeopsis is listed as Rare under the California Endangered Species Act, and in Category 1B on the CNPS's list of rare, threatened, or endangered plants in California and elsewhere (CNPS 2003). Historically, this plant was widespread from the Napa River in Napa County, east to Suisun Bay and Marsh, and the Sacramento and San Joaquin Rivers and their channels and tributaries in Contra Costa, Solano, Sacramento, Yolo, and San Joaquin Counties (DFG 2001). Today, it occupies much the same range, but has declined greatly in population size (DFG 2001). This tiny turf-forming plant occurs today in colonies from one square foot to 700 square meters, and may be locally common in Suisun Bay (CNDDB 2003, CNPS 2003, DFG 2001).

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, SRCD 1998). It has also been observed to occur on wave cut sandy beaches, earthen levees with a clay substrate, and on old pilings or snags (CNDDB 2003, DWR 1999). Because eroding slough banks are constantly being washed away and reformed, individual plant populations are always in flux, and have been known to float as clonal tufts (ramets) to colonize new locations (DWR 1999). Water salinity, mean tidal elevation, tidal range, soil type, and active bank erosion determine the distribution of Mason's lilaeopsis (DWR 1999). It often occurs with other rare plants, such as Suisun Marsh aster and Delta tule pea (CNDDB 2003).

Mason's lilaeopsis is threatened by levee construction and maintenance (especially where riprap is used), widening of Delta channels for water transport, dredging and dumping of spoils, recreation, development, cattle grazing, agriculture, trampling, water ski and boat wakes, bank erosion, possible oil spills, and potentially changes in water quality resulting from decreased flows in the Delta (CALFED 1999, CNPS 2003, CNDDB 2003, DWR 1999, SRCD 1998). Mason's lilaeopsis is further threatened by shading resulting from common reed (*Phragmites australis*), and competition with non-natives giant reed (*Arundo donax*), pampas grass (*Cortaderia selloana*), and perennial pepperweed (CNDDB 2003, CNPS 2003). Water hyacinth (*Eichhornia crassipes*) itself and water hyacinth control can both have negative effects on Mason's lilaeopsis (CNDDB 2003, CNPS 2003).

Presence of Mason's lilaeopsis in Suisun: Mason's lilaeopsis is locally common in the northern, central, and eastern regions of the Suisun Bay and Marsh. It is also abundant on the uninhabited islands in Suisun Bay, where there is no riprap and little human disturbance (CALFED 1999, DWR 1999). A marsh-wide survey conducted in 1992 as part of the biological assessment for the State Water Resources Control Board and surveys between 1990 and 1993 for the Western Suisun Marsh Salinity Control Project found the species throughout Suisun, with the highest density observed along Suisun and Montezuma Sloughs (DWR 1999). The largest continuous population was observed along the west bank of Suisun Slough opposite Rush Ranch (DWR 1999).

Presence of Mason's lilaeopsis in diked wetlands of Suisun: Mason's lilaeopsis is found on the outboard side of levees throughout Suisun Marsh where there is no riprap or other extensive disturbances (DWR 1999).

Measures currently taken to preserve species: A recovery plan has not been prepared and recovery requirements have not been identified for this species (CALFED 1999). SRCD recommends that the landowner of property containing Mason's lilaeopsis keep the area undisturbed and notify SRCD upon finding the species (SRCD 1998). Relocation of discharge facilities, such as slide and flap gates, or fish screen installation on the exterior levees may negatively affect this species as would levee maintenance, especially the addition of riprap (DWR 1999).

Table B-1.0 Requirements, Habitat Values, and Acreage of Key Plants in Suisun Marsh

Species Common Name	Species Scientific Name	Food Value[1]	Cover Value[1]	Nesting Value[1]	Soil/water Salinity Tolerance (MS/cm)	Water Management/ Planting Schedule	Use Control Measures/ Desirable vs. Undesirable	Acreage in 2000 in diked lands[2]	Notes
Fat hen	*Atriplex triangularis*	Good	Good	Moderate	20-77	I - Traditional Fat Hen/ Short Hydroperiod		2,053	
Lamb's quarters, Pigweed	*Chenopodium album*	Good	Good	Poor	Up to 62	I - Traditional Fat Hen/ Short Hydroperiod		unknown	
Brass buttons	*Cotula coronopifolia*	Good	Poor	None	14-48			416	
Swamp timothy	*Crypsis schoenoides*	Good	None	None	Up to 5			74	Excellent waterfowl plant, esp. northern pintail
Watergrass	*Echinochloa crus-galli*	Good	Good	None	Up to 7	H - Traditional Watergrass		1090	
Smartweed	*Polygonum* spp.	Good	Good	None	Up to 5	H - Traditional Watergrass		1090	
Sago pondweed	*Potamogeton pectinatus*	Good	None	None	14-18			32	Supports high numbers of invertebrates
Wigeongrass	*Ruppia maritima*	Good	None	None	5-23			unknown but not abundant	Supports high numbers of invertebrates
Pickleweed	*Salicornia virginica*	Good	Moderate	Poor	48-105	J - Pickleweed Schedule	New growth more desirable - disc 20% per year	12,380	Supports high numbers of invertebrates
Tules	*Scirpus acutus*	Poor	Good	Good - for Passerines	Up to 17	C - Permanent Pond or A, B, D	Undesirable when dominates pond or obstructs water flow	2389	

Species Common Name	Species Scientific Name	Food Value[1]	Cover Value[1]	Nesting Value[1]	Soil/water Salinity Tolerance (MS/cm)	Water Management/ Planting Schedule	Use Control Measures/ Desirable vs. Undesirable	Acreage in 2000 in diked lands[2]	Notes
Alkali bulrush	*Scirpus maritimus*	Good	Good	None	Up to 42 for mature plants, 11-22 for germination	A, B, G		2,478	
Sea purslane	*Sesuvium verrucosum*	Good	Poor	None	Up to 100 mS/cm			573	
Cattail	*Typha* spp.	Poor	Good	Good - for Passerines	Up to 15 mS/cm	C - Permanent Pond or A, B, D	Undesirable when dominates pond or obstructs water flow	4955	
Quail brush, Big saltbush	*Atriplex lentiformis*	Poor	Good - for upland species and passerines	Good - for Passerines				26	Good pheasant cover
Wild oat	*Avena fatua*	Good - for ungulates and upland game	Good	Good			Occasional mowing, burning, discing to renew growth	unknown	
Coyote brush	*Baccharis pilularis consanguinea*	Poor	Good - for upland species and passerines	Good - for Passerines			Undesirable when dense on levee trails	92	
Wild mustard	*Brassica* spp.	None	Good	Good				unknown	
Brome	*Bromus* spp.	Good - for ungulates and upland game	Good	Good			Occasional mowing, burning, discing to renew growth	8	

Species Common Name	Species Scientific Name	Food Value[1]	Cover Value[1]	Nesting Value[1]	Soil/water Salinity Tolerance (MS/cm)	Water Management/ Planting Schedule	Use Control Measures/ Desirable vs. Undesirable	Acreage in 2000 in diked lands[2]	Notes
Tall wheatgrass	*Elytrigia elongata*	Good - for ungulates and upland game	Good	Moderate			Occasional mowing, burning, discing to renew growth	86	Good pheasant cover
Barley	*Hordeum* spp.	Good - for ungulates and upland game	Good	Good			Occasional mowing, burning, discing to renew growth	2	Ducks eat seeds in September to early October
Italian rye grass	*Lolium multiflorum*	Good	Good	Good			Occasional mowing and burning	264	
Harding grass	*Phalaris* spp.	Good - for ungulates and upland game	Good	Moderate			Occasional mowing, burning, discing to renew growth	22	
Rabbitsfoot grass	*Polypogon monspeliensis*	Good	Moderate	Poor	saturated brackish to saline soils			54	
Wild radish	*Raphanus sativus*	None	Good	Good				unknown	
California rose	*Rosa californica*	Good - for passerines	Good	Good - for Passerines				202	Good for stabilizing slough banks
Blackberry	*Rubus* spp.	Good	Good	Good - for Passerines				54	Good for stabilizing slough banks
Curly dock	*Rumex crispus*	Poor	None	Poor				16	
Vetch	*Vicia* spp.	Good - for upland birds	Good	Good		Sow seeds in September to October		unknown	
Giant cane	*Arundo donax*	None	None	None			Mechanical or herbicide removal	2	

Species Common Name	Species Scientific Name	Food Value[1]	Cover Value[1]	Nesting Value[1]	Soil/water Salinity Tolerance (MS/cm)	Water Management/ Planting Schedule	Use Control Measures/ Desirable vs. Undesirable	Acreage in 2000 in diked lands[2]	Notes
White-top	*Carderia pubescens*	Poor	Moderate	Moderate			Herbicide removal (Telar)	unknown	
Poison hemlock	*Conium maculatum*	None - lethal if eaten	Moderate	Poor			Herbicide removal (Roundup or Aquamaster)	290	
Pampas grass	*Cortaderia selloana*	None	None	Moderate - rabbits, passerines			Mechanical or herbicide removal	6	
Saltgrass	*Distichlis spicata*	Poor	None	Poor	Up to 12		Burning, discing, flooding	9569	
Fennel/Anise	*Foeniculum vulgare*	Poor	Moderate	Poor			Mowing	81	
Baltic rush	*Juncus balticus*	None	Moderate	None	Up to 15		Mechanical or herbicide removal	1091	
Perennial pepperweed	*Lepidium latifolium*	None	Poor	Poor			Herbicide removal (Telar)	682	Control invasions early. Difficult to eradicate when established.
Phragmites, Common reed	*Phragmites australis*	None	Good	None	Up to 20		Mechanical or herbicide removal	479	
Cocklebur	*Xanthium strumarium*	None-poisonous	Moderate	None	Up to 15		Mowing, flooding, herbicides	1099	

[1] Plant food, cover, and nesting values are for waterfowl unless otherwise noted. Ratings from best to worst: Good, Moderate, Poor and None.
[2] Diked wetland acreages include diked areas not managed for waterfowl as well as diked areas managed for waterfowl.

Table B-2.0 Listed plant species occurring on managed wetlands or might be directly impacted by managed wetland practices.

Common Name	**Scientific Nomenclature**	**Federal Status**	**State Status**	**Other**
Suisun marsh aster	*Aster lentus*	Formerly Species of Concern		
Alkali milkvetch	*Astragalus tener var. tener*	Formerly Species of Concern		CNPS list 1B
Heartscale	*Atriplex cordulata*	Formerly Species of Concern		CNPS list 1B
Brittlescale	*Atriplex depressa*	Formerly Species of Concern		CNPS list 1B
Valley spearscale	*Atriplex joaquiniana*	Formerly Species of Concern		CNPS list 1B
Contra Costa goldfields	*Lasthenia conjugens*	Endangered		CNPS list 1B
Delta tule pea	*Lathyrus jepsonii*	Formerly Species of Concern		CNPS list 1B

Appendix C

Resident and Migratory Wildlife Discussion and Impacts

C-1 HARVESTED SPECIES

Migratory Waterfowl

As one of the largest, contiguous areas of remaining habitat, the Marsh provides important waterfowl habitat in California. Suisun Marsh represents approximately 13% of California's remaining wetlands and has historically wintered up to 28% of the wintering waterfowl in California. Studies in the Marsh and Central Valley have shown that waterfowl may use the Marsh as a permanent wintering area, as a stop over point in a continued migration, or opportunistically depending upon regional habitat availability (Miller 1987). As more wintering habitat is lost, Suisun managed wetlands will become increasingly valuable to migratory waterfowl.

The Marsh provides the first available water for most wintering waterfowl in California. Waterfowl populations peak in October and early November when wetland habitat in the State is limited. Because water is already limited at peak population levels, Suisun is especially important to waterfowl in times of drought. Marsh water supplies remain very stable while Central Valley water supplies are reduced during times of drought. Water reductions in the Central Valley create a situation where many areas outside of Suisun may not be flooded, further reducing waterfowl habitat. As habitat is reduced, waterfowl populations in flooded areas become overcrowded making populations more susceptible to diseases such as cholera and botulism.

The most common groups of migratory waterfowl using Suisun managed wetlands for wintering habitat are dabbling ducks, diving ducks, sea ducks, whistling ducks, stiff-tailed ducks, geese, and swans. The Marsh provides important foraging habitat for dabbling ducks (Connelly and Chesmore 1980, Euliss and Grodhaus 1987, Euliss and Harris 1987, Miller 1987, Euliss et al. 1991, Batzer et al. 1993) such as: mallard, gadwall, Northern pintail, Northern shoveler, American wigeon, Eurasian wigeon, Cinnamon teal, green-winged teal, and blue-winged teal. Diving ducks using the Marsh include: canvasback, redhead, ring-necked duck, greater scaup, and lesser scaup. Sea ducks using managed wetlands in the Marsh include: common goldeneye, Barrow goldeneye, black scoter, white-winged scoter, surf scoter, common merganser, hooded merganser, red-breasted merganser, and bufflehead. A variety of geese also use managed wetlands including: Canada geese, tule greater white-fronted geese, and snow geese. The Suisun Marsh provides a variety of food items such as invertebrates, seeds, and other plant material for these waterfowl.

In the Marsh, waterfowl hunting is permitted each year from mid October to mid January. Hunters use the Marsh 50,000 hunt days per year. During the hunting season, closed zones on DFG lands provide refuge from hunting and alternate feeding and loafing areas.

Resident Waterfowl

Resident waterfowl depend on habitat in the Marsh year round, especially for breeding, nesting, and brood habitat

The Suisun Marsh has been found to provide high quality nesting habitat for mallards, teal, shoveler, and wood ducks. McLandress et al. (1996) found that key nesting densities on major wetland complexes in California, including the Marsh, are as high, or higher, than nesting densities in northern breeding areas. Mallard nest densities in California were found to be much higher than the prairies of Canada (10.6/ km^2) (Greenwood et al. 1987) and several northern U.S. states (3 to 35 nest/ km^2) (Higgins et al. 1992, Fleskes and Klass 1991). In California, the highest nest densities (190 nests/km^2) were found in the Suisun Marsh demonstrating its importance as a nesting area for waterfowl (McLandress et al. 1996).

Grizzly Island Wildlife Area provides semi-permanent wetlands that provide key brood habitat (see section C. Permanent water/Brood ponds, page 29) for waterfowl and shorebirds as well as summer water essential to resident waterfowl and wildlife. These areas are flooded approximately from February 1 to September 15 each year. Nesting habitat is available in large sections of uplands at the GIWA (1200 contiguous acres/ 485 hectares) and along pond margins spread over the Marsh. In Suisun, waterfowl nesting can occur as early as March and continues through August.

Ring-necked Pheasant

The ring-necked pheasant is a non-native year round resident of the Suisun Marsh. GIWA manages approximately 180 acres of Diversified Upland Habitat Units (DUHUs). These upland fields are managed as nesting areas for pheasant and waterfowl. These DUHUs also provide food and cover benefits for passerines and other wildlife species (GIWA staff pers. comm.).

A pheasant hunting program is offered every year on Grizzly Island Wildlife Area property. The hunt begins the second weekend in November and extends for 44 days.

Tule Elk

Tule elk were reintroduced to Grizzly Island in 1977. A herd of approximately 125 elk live on Grizzly Island proper. Tule elk live primarily on the Grizzly Island managed wetlands and adjacent private lands. The elk use wetlands and adjacent uplands for foraging on grasses, forbs, and shrubs, and for calving. The herd does not emigrate from Grizzly Island. Tule elk provide wildlife viewing and hunting opportunities. The growing population on Grizzly Island also provides stock for reintroduction to other areas.

Grizzly Island Wildlife Area offers an annual tule elk hunting program. The elk hunting program encompasses five separate periods each fall on Grizzly Island. Thirty seven animals are taken each year and include antlered & spike bulls, and cows. Other than the yearly hunt program, GIWA does not currently conduct any other management of the tule elk herd (GIWA staff pers. comm.).

Pigs

Pigs are found on the Grizzly Island Wildlife Area, Joice Island Unit. A private landowner, on private land, introduced them 12 years ago. Recent observations have confirmed the spread of pigs to the adjacent Rush Ranch property.

Pigs are omnivorous, feeding on underground tubers, grasses, berries, and small mammals. They have been found to destroy native vegetation and nests of ground-nesting birds by rooting through the ground (Wood and Barrett 1979).

A hunt program has been ongoing for the last 5 to 6 years with very low success (GIWA staff pers. comm.). Impacts of pigs on managed wetlands are unclear, though pigs have been found to root up large areas of vegetation in Suisun. No current studies are being conducted, but managers believe the population is increasing.

C-2 OTHER SPECIES OF IMPORTANCE

Egrets and Herons

Several rookeries of great blue herons, snowy egrets, great egrets, and black crowned night herons are found in taller shrub vegetation and eucalyptus trees that occur along pond levees adjacent to managed wetlands in the Marsh. These birds are seen feeding in managed wetland ponds and along water delivery ditches.

It is unclear how wetland management and fish screens may impact these species. Foraging is enhanced when fish and invertebrate populations are concentrated during spring drawdowns. When fish screens are in place, fish are no longer able to enter managed wetland ponds making that food item unavailable on managed ponds.

Other water birds

A number of other water birds including Virginia rail, pelicans, cormorants, grebes, moorhens, and others use managed wetlands at various times of the year. Managed wetlands provide a variety of foraging habitat for these birds. Many species like grebes utilize only permanently flooded areas such as water delivery ditches and permanent ponds, while others like pelicans use drier mudflats for loafing and feed in flooded managed wetlands.

Managed wetlands also provide nesting habitat for some water birds. Management practices that manipulate or disturb wetland vegetation during the nesting season may negatively impact ground-nesting birds.

Raptors

A number of hawks, falcons, and accipiters use the Marsh for foraging and nesting. The more common species using managed wetlands are turkey vultures, white-tailed kites, Northern harriers (harriers are discussed in detail on page 88), eagles, sharp-shinned hawks, Cooper's hawks, red-shouldered hawks, red-tailed hawks, and American kestrels. Winter or seasonal visitors include rough-legged hawks, ferruginous hawks, and peregrine falcons (ferruginous hawks and peregrine falcons are discussed in detail on pages 88 and 89 respectively).

Managed wetlands and adjacent uplands provide foraging and nesting areas for many of these raptors. Some species like eagles may travel significant distances from the adjacent coastal ranges to forage in the Marsh.

Studies in the Suisun Marsh have found that raptor nests in proximity to waterfowl nests improved waterfowl nesting success, possibly due to raptors protecting their own nests from predators (Ackerman 2002).

Owls

Resident owls include great horned, short-eared owl, barn owl, screech owl, and burrowing owls. Managed wetlands and adjacent uplands provide foraging and nesting areas for many of these owl species. No studies have been completed to determine owl use of managed wetlands or the impact of managed wetland management to owls.

Waterfowl studies in the Marsh have found that waterfowl nesting in proximity to ground nesting owls had improved nesting success. The connection between owl nests and improved waterfowl nesting success is possibly due to owls protecting their own nests from other predators (Ackerman 2002).

Shorebirds

The loss of natural wetlands in California poses a real threat to shorebirds because, like waterfowl, they rely on wetlands throughout the year. Habitat losses highlight the need for management of breeding and migrating shorebirds on public and private lands in the Suisun Marsh. Breeding shorebirds nest in a wide range of habitats from unvegetated wetland flats to moderately tall, dense upland grasses. For many breeding shorebirds, landscape juxtaposition of habitats is important. Temporary ponds are valuable early in reproduction, whereas seasonal, semi-permanent, and brackish wetlands provide foraging habitat throughout nesting and brood rearing (Eldridge 1992). Spring drawdowns practiced by Suisun Marsh wetland managers provide ideal habitat for migrating and nesting shorebirds, although management that alters vegetation in nesting areas may have a negative impact to nesting birds.

Many shorebird species use the Marsh either seasonally or opportunistically based on regional habitat availability. Some of these include: avocets, curlews, dowitchers, phalaropes, sandpipers, stilts, and yellowlegs.

Passerines

Many passerines species inhabit the Marsh using it for nesting and foraging. These passerines include residence, transient, and migrant species.

Many passerine species are unstudied in the Suisun Marsh. Due to a lack of information on these species, uncertainties exist on how wetland management may affect these species and how these species use managed wetlands. Some studies are currently gathering information on common yellow throat and Suisun song sparrow. One study by Point Reyes Bird Observatory is currently investigating avian use of managed, tidal, and restored habitats.

Bats

It is believed that a number of bat species forage in the Marsh. These species may be permanent residents or seasonal migrants using the Marsh during their migration from the Sierras to the coast. Bats may play an important role in mosquito control in Suisun and may be negatively impacted by external mosquito control measures. While there are some known colonies within Suisun City no large colonies have been found in the Suisun Marsh. The lack of roost sites may be one contributing factor for the absence of large colonies in the Marsh. Limited roosting in bridges, windbreaks, and buildings may occur in the Marsh. No current studies are being conducted on bats in or around Suisun.

C-3 SUISUN MARSH MANAGED WETLAND LISTED AND SENSITIVE SPECIES

Several State and federal listed or protected species are found in the Suisun Marsh. Wetland managers must follow State and federal restrictions in their day-to-day operations to protect these species and their habitats. Species with State and federal status using managed wetlands or possibly being impacted by wetland management are addressed below. Species of Concern are also presented though the species has no official State or federal status. Additional information concerning restrictions on wetland management can be found in the *Regulatory section* (page 100).

Salt Marsh Harvest Mouse

The salt marsh harvest mouse (*Reithrodontomys ravivetris 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 DFG Fully Protected Species. A recovery plan for the species was prepared by the USFWS in 1984 and is currently under revision. In the recovery plan, the USFWS did not declare any critical habitat within the Suisun 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 Suisun.

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. Ongoing genetic studies of the SMHM in the Marsh show that the population is genetically diverse (Brown 2003). 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. To minimize impacts to the SMHM on managed wetlands, discing in pickleweed habitat is voluntarily limited to 20% of landowner acreage (SRCD pers. comm.). 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 elucidate the relationship between seasonal demography and microhabitat characteristics in the Suisun 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.

Bats

See discussion of bat use and impacts on page (page 86).

Suisun Ornate Shrew

The Suisun shrew (*Sorex ornatus sinuosis*) is a DFG and federal Species of Special Concern. As such, the species has no official State or federal status though it is considered in Environmental Assessments, Environmental Impact Reports, and Environmental Impact Statements. Very little is known about the Suisun shrew, as there have been very few recent captures and the historical literature is limited.

Historically, Suisun shrews were found in a number of Marsh localities. Museum specimens of Suisun shrews were taken from the Cordelia salt marsh, 1.5 miles southwest of Suisun, Grizzly Island, Van Sickle Island, and Suisun City. During the mid-1980s surveys identified only one Suisun shrew that was found dead on the road near the DFG headquarters (Williams 1983). Currently, unidentified shrews are being found in several locations on DFG managed wetlands in the north and west portions of the Marsh.

Shrews have been captured along upland edges or areas adjacent to levees. Actual managed wetland use and overall distribution in Suisun are unknown. There are no current studies being conducted in Suisun to further investigate the Suisun shrew’s distribution and habitat use. However, DFG and DWR biologists may begin a genetics study to identify shrews captured during SMHM studies.

American Bittern

The American bittern (*Botaurus lentiginosus*) is designated as a federal Species of Concern.

The bittern is a year-round resident of the Suisun Marsh. Dense cattail and bulrush marshes are used for breeding and foraging. Shallow flooded areas and moist grassy, herbaceous uplands may also serve as foraging habitat. While managed wetlands provide habitat for foraging and nesting, manipulation of those habitats may negatively impact bitterns.

The frequency, number, and distribution of American bittern in the Marsh are not well known due to lack of studies.

Golden Eagle

The golden eagle (*Aquila chrysaetos*) is a DFG Species of Concern and Fully Protected Species. Eagle territories are estimated to average 48 mi^2 (Smith and Murphy 1973) and require secluded cliffs for cover and nesting.

Golden eagles are a permanent transient species in Suisun as they continually travel to and from the Suisun area using the Marsh primarily for foraging. Eagles may travel long distances from the coastal ranges and Mount Diablo to forage on Suisun mammals and waterfowl. Managed wetlands are believed to benefit the golden eagle population since managed wetlands attract and produce prey for the eagle.

Ferruginous Hawk

The ferruginous hawk (*Buteo regalis*) is listed as a DFG and federal Species of Concern. This hawk is a common winter resident of grasslands and agricultural areas. They generally winter in California from September through March.

Ferruginous hawks are seen in Suisun during the winter roosting on telephone poles. No current studies are being conducted on this species, but wetland management practices are not thought to affect winter foraging habitat for ferruginous hawks.

Northern Harrier

The northern harrier (*Circus cyaneus*) is a DFG Species of Concern.

In the Marsh, harriers are a resident species. They may be seen throughout the Marsh soaring over wetland and grassland vegetation searching for food. Harriers are ground nesters using grasslands and emergent wetlands as nesting habitat. Northern harriers breed and nest from April to September with peak activity in June through July (Zeiner 1990). Ackerman (2002) found that nesting raptors might actually protect adjacent waterfowl nests and improve nesting success.

No current studies are being conducted on harriers. Wetland management practices that manipulate vegetation for waterfowl nesting is expected to also provide nesting habitat for these ground-nesting birds. However, if vegetation manipulation is conducted in wetland habitats while harriers are nesting, there could be a negative impact to the nesting birds.

White-tailed Kite

The white-tailed kite (*Elanus leucurus*) is a federal Species of Concern and a DFG Fully Protected Species.

In the Marsh the kite is a common resident and may be found foraging over the wetlands and grasslands, and nesting in the trees. Kites feed on small mammals and most other small animal and insect species. Kites are generally found nesting in trees 20-100 feet above the ground (Zeiner 1990). Roosting and nesting is limited due to the shortage of trees in the Marsh. No current studies are being conducted on this species, but wetland management practices are not expected to affect foraging or nesting habitat for kites.

American Peregrine Falcon

The American peregrine falcon (*Falco peregrinus anatum*) was listed as federally endangered in 1970 and listed as endangered by the DFG in 1971. A ban on the use of DDT, combined with successful captive breeding and release programs, has resulted in the apparent recovery of peregrine falcons in California and over much of the rest of the species former North American range. The species was removed from State and federal threatened and endangered species lists in 1999, but remains a DFG Species of Concern.

The San Francisco Bay and Delta region is considered an important wintering area for the peregrine. As many as 20 peregrine falcons seasonally inhabit the area (Harvey and others 1992).

In the Bay Area, peregrine falcons prey opportunistically on shorebirds, pigeons, terns and several passerine species (Harvey and others 1992). Telemetry studies in the Bay Area have also shown substantial use of transmission line towers as perching sites. At least one pair of peregrine falcons nests in the Suisun Bay area and as many as 20 birds winter in and nearby Suisun (Harvey1988).

No current studies are being conducted on this species, but wetland management practices are not expected to affect foraging or nesting habitat for this species.

California Black Rail

The California black rail (*Lateralus jamaicensis coturniculus*) is a federal Species of Concern, State threatened, and DFG Fully Protected Species. The majority of the black rail population is associated with the tidal marshlands of the San Francisco Bay Estuary

(Goals Project 2000). Other populations exist in freshwater habitats of the Sierra foothills (Aigner et al. 1995).

In 1992 nesting black rails were believed to be patchily distributed in Suisun (SFEP 1992). Current thinking is black rails may be more widely distributed in Suisun than previously understood (Goals Project 2000). Studies completed in 1996 found stable populations in Suisun Bay (Nur et. al. 1997). Currently, Spautz et. al. (2002) are conducting a continuing study of black rail populations in Suisun tidal wetland habitats. Other studies have documented black rail presence on managed wetlands, but it is uncertain how black rails may use managed wetlands and how wetland management may affect them. Evidence suggests black rails used managed wetlands when those managed wetlands are adjacent to tidal wetlands (Estrella pers. comm.).

California Clapper rail

The clapper rail (*Rallus longirostris obsoletus*) is a federal and State listed endangered species and a DFG Fully Protected Species. The USFWS 1994 Biological Opinion restricts maintenance activities in or adjacent to tidal marsh habitat during the clapper rail 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.

Clapper 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). Early studies that looked at the historic distribution of clapper rails found no documentation of presence for Solano County, including the Marsh and portions of the Napa Marsh (Gill 1979). Many older surveys of the Marsh have no documented observations of clapper rail (Gould 1973).

Harvey (1980) did find clapper rails along several tidal marshes and sloughs around the Suisun Marsh, and surveys conducted from 1991 to 1994 found several nesting pair of clapper rail. However, surveys and incidental observations conducted since 2002 have documented only eight individuals. There is some indication that populations may be present in Suisun some years and not others and winter records appear to be more numerous than breeding season records (Goals Project 2000). The decrease in freshwater outflow has resulted in the conversion of these marshes to more brackish conditions, thus possible leading to a range expansion into this area (Evans and Collins 1992).

Long-billed Curlew

The long-billed curlew (*Numenius americanus*) is a DFG and federal Species of Concern. It is known to feed on intertidal mudflats and upland herbaceous areas and croplands. Changes to vegetation in these habitats may affect curlew food resources.

In the Marsh the curlew is considered a winter migrant, using the Marsh for foraging and resting**.**

Short-eared Owl

The short-eared owl (*Asio flammeus*) is a DFG Species of Concern. Short-eared owls are found in open areas with few trees. Numbers throughout their range have declined due to destruction and fragmentation of grassland and wetland habitats (Zeiner 1990).

In Suisun the short-eared owl is considered a resident and migratory species. It can be found nesting in upland areas managed for waterfowl nesting. Wetland management practices that create habitat for waterfowl nesting are expected to also provide nesting habitat for these ground nesting birds. Ackerman (2002) found that nesting owls may actually protect adjacent waterfowl nests and improve nesting success.

Western Burrowing Owl

The western burrowing owl (*Athene cunicularia hypugea*) is classified as a DFG and federal Species of Concern.

In the Marsh, burrowing owls have been sighted in upland areas near Collinsville and in the upland area at Rush Ranch where they take over burrows dug by ground squirrels. Other existing populations of burrowing owls may occur near upland areas around the margins of the Marsh where ground squirrels and associated burrows may occur. In general, managed uplands do not use rodent control allowing for ground squirrel use and therefore, creating burrowing owl burrow habitat. Burrow habitat is a major limiting factor for burrowing owl populations throughout their range (Johnson 2004).

No current studies are being conducted on this species, but wetland management practices are not expected to affect foraging or nesting habitat for this species.

Loggerhead Shrike

The loggerhead shrike (*Lanius ludovicianus*) is a DFG and federal Species of Concern. Shrikes prefer open habitats with scattered shrubs, trees, posts, and fences (Zeiner 1990). Populations remain somewhat stable in California (Morrison 1981).

In Suisun, the shrike is considered both a resident and migrant species. Shrikes can commonly be seen along Grizzly Island Road, Rush Ranch, and other areas that provide roosting habitat. It is uncertain how this species uses managed wetlands and how wetland management may affect this species.

Salt Marsh Common Yellowthroat

The salt marsh common yellowthroat (*Geothlypis trichas sinuosa*) is a DFG and federal Species of Concern. The salt marsh common yellowthroat is found all year in the San Francisco Bay region. To date, the breeding range of the salt marsh common yellowthroat is undefined (Marshall and Derrick 1994) but it is believed to breed in fresh and brackish marshes around the inland margins of San Francisco Bay, east to Carquinez Straits, and in coastal marshes from Tomales Bay to Pescadero Marsh (Foster 1977). Salt marsh common yellowthroats migrate from fresh to brackish marsh breeding sites and to bay - ward salt marshes in the fall when seasonal emergent marsh vegetation dies back (Foster 1977). The birds are most often observed in coyote bush (*Baceharis pilularis*) or emergent tule (*Scirpus* spp.) and cattail (*Typha* spp.) stands close to the water.

The Grizzly Island population of salt marsh common yellowthroats includes two subspecies, *Geothlypis trichas sinuosa* (salt marsh common yellowthroat) and *G.t. arizela* (western yellow throat). Raby (1992) found that the Grizzly Island area represented a zone of integration between these two subspecies. Salt marsh common yellowthroats were captured with mist nets and banded at Joice Island in the Marsh, the Suisun Bay shoreline near Benicia, and the Benicia State Recreation Area to determine the sub-specific identity of yellowthroats in Marsh and the Carquinez Straits (Hobson et al 1986). The results of these surveys were inconclusive. Common yellowthroats are often seen in tall emergent vegetation within managed and tidal wetlands of the Marsh, but it is unknown if these populations are *G.t. sinuosa*.

<u>Suisun Song Sparrow</u>

The Suisun song sparrow (*Melospiza melodia maxillaris*) is a federal and DFG Species of Concern. Nur et. al. found that this species is locally common in tidal wetlands of Suisun Marsh (1997). Larsen (1989) found Suisun song sparrows marginally use upland plants along levees and avoided diked marshes with *Salicornia* and *Grindelia*. Marshall and Derrick (1994) found that while fully intertidal brackish marsh was the prime habitat they did find about 3% using non-tidal territories.

Surveys for this species are ongoing at Rush Ranch. A new study by Point Reyes Observatory is investigating avian use of managed, restored, and tidal wetlands of Suisun. This study may answer whether Suisun song sparrow use managed wetlands and if so, how management activities impact the species.

<u>Western Pond Turtle</u>

The western pond turtle (*Clemmys marmorata*) includes two subspecies, the northwestern pond turtle (*C. m. marmorata*) and the southwestern pond turtle (*C.m. pallida*). The western pond turtle is listed as a federal and DFG Species of Concern. The northwestern pond turtle is found north of San Francisco Bay, while the southwestern pond turtle is found south of San Francisco Bay. There is evidence to suggest that the two subspecies may intergrade between the San Francisco Bay region and the San Joaquin Valley.

Marsh-wide, pond turtles are most commonly observed basking on the banks of channels during daylight low tides. In managed wetlands, turtles are seen primarily during spring draw-down, basking on pipes or debris in the larger drainage ditches (Steve Chappell, pers. comm.). The species is fairly sedentary, with home ranges of approximately one hectare for males and 0.3 hectare for females, but they can move considerable distances (1.5 km or more) usually within the same drainage (Holland 1991). It is not known where the turtles over winter in the Marsh, where they nest, or where hatchlings and juveniles are located. It is also unknown whether management activities impact this species, although structures on managed wetlands provide basking sites.

Sensitive or Listed Fish Species

There are many natural and man-made conditions in Suisun Marsh that may impact fish species. Natural factors such as tides and freshwater outflow affect how and when fish species use the Marsh. Man-made factors such as salinity manipulation through the SMSCG and the State and federal water projects as well as management practices on wetlands may also affect fish species.

Freshwater outflow and operations of the SMSCG operations are the primary factors affecting salinity in the Suisun Marsh. The SMSCG is operated to keep the salinity in the Suisun Marsh below salinity standards created to keep water fresh enough for managed wetlands to operate. Operation of the SMSCG lowers salinity certain times of the year reducing salinity variability in Suisun Marsh. In the 2001 Suisun Ecological Workgroup Report, the Aquatic Habitat Subcommittee found that while salinity conditions in the Marsh did not impact adult and juvenile fish, it may be limiting to spawning and larval rearing of native fish (DWR 2001). Schroeter and Moyle (2001) also report that while native species are positively influenced by variable salinity conditions, which have been dampened by the SMSCG, the majority of alien species are almost entirely dependent on freshwater. Schroeter and Moyle (2001) have also noted that native species abundance does not fluctuate as widely as alien species abundance in response to the water year type as well as the amount and timing of freshwater outflow.

Periodic low dissolved oxygen events in the sloughs may also impact fish using Suisun. Water discharged from managed wetlands, laden with organic matter, seems to be responsible for isolated fish kills. Incidental observations in Suisun have noted fish kills in areas of low dissolved oxygen near managed wetland drains during drain cycles (Schroeter and Moyle 2001). Additional information is still being collected.

It is uncertain with current regulatory restrictions on managed wetland intakes, whether there is an entrainment impact to fish species from managed wetlands. It is also uncertain whether fish that are entrained are able to return to the sloughs through the drain process. It is possible that managed wetlands function more like a floodplain than an agricultural field when viewed in terms entrainment issues.

See Appendix D for wetland management restrictions based on protection of listed fish species.

Below are brief descriptions of listed fish species found in Suisun. Further information can be found in the species models.

Pacific Lamprey

Pacific lamprey (*Lampetra tridentata*) is designated as a federal Species of Concern.

Pacific lampreys were first reported in the Sacramento-San Joaquin river system by Rutter (1907). In recent years, this species has been caught with trawls in San Francisco Bay (Aplin 1967), San Pablo Bay (Ganssle 1966), and Carquinez Strait (Messersmith 1966). Pacific lamprey have more recently been found in Cache Slough, Lindsey Slough, Suisun Bay, American River (up to Nimbus Dam), the Sacramento River (up to Red Bluff Dam), Napa River, Sonoma Creek, and Walnut Creek.

Pacific lampreys are a migratory and transient species in the Marsh. They have been captured somewhat infrequently by the University of California (UC) Davis Suisun Marsh Sampling Program (Matern et al 1997). These fish have only been captured during nine of the 19 years of the study, in 1981, 1982, 1986, 1987, 1992, and 1995 through 2000. During five of those years, only one lamprey was caught, while in 1981, 1982, and 1992 between two and six were captured. In 1995, nineteen Pacific lampreys were captured. The Marsh is not identified as a spawning ground for this fish (Wang 1986; Matern et al 1997), so individuals captured may be migrating from or to tributary creeks, or the Sacramento and San Joaquin Rivers or tributaries.

Green Sturgeon

Green sturgeon (*Acipenser medirostris*) is designated a DFG Species of Concern. In California, green sturgeon have 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 Suisun Marsh, green sturgeon are primarily transient or migratory. Matern (1997) reported that surveys from 1979 through 1997 in the Suisun 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 fresh water environments (Moyle 1995).

Chinook Salmon

There are four runs of Chinook salmon (*Oncorhynchus tshawytscha*) that are distinguished by the timing of adult upstream migration and the spawning season: fall, late-fall, winter and spring runs. In 1989, the Sacramento River winter-run Chinook salmon was listed as threatened under the Federal Endangered Species Act. It was listed as federally and State endangered in 1994. In 1993, critical habitat for the winter-run Chinook was designated from Keswick Dam (Sacramento River mile 302) to the Golden

Gate Bridge. Central Valley spring run Chinook salmon was listed as federally threatened in August 1998 and State threatened in February 1999. The Central Valley late-fall run are listed by DFG as a Species of Concern.

Numbers of this native, anadromous species, which is distinguished by its highly variable life history and multiple stocks, are maintained to a large extent by hatchery production (SFEP 1992). The Central Valley supports the largest population of Chinook salmon in the State (SFEP 1992). The Bay-Delta estuary serves as a migratory corridor for returning adults and emigrating smolts, and serves as rearing habitat for salmon fry.

Adult Chinook salmon migration and their presence in Suisun Marsh/Bay varies for each race of salmon. Adult winter-run migrate through Montezuma Slough and Suisun Bay from November through mid-June. Juveniles may occur in the Marsh from September through May, with especially high numbers occurring from January through April. Adult spring-run may occur in the Montezuma Slough or Suisun Bay from February through June, with the peak migration occurring in May. Juveniles may be migrating through the Marsh December through May. Fall-run adults may occur in the area June through December, while juveniles may be present from January through July, with the peak occurrence from February through mid- May. The presence of juvenile Chinook salmon in the Marsh has varied over the years according to the results of the UC Davis sampling. Chinook salmon were captured in trawls in all but two years between 1980 and 1989, they were not captured subsequently until 1995, when a total of fifty individuals were collected (Matern 1996). In 1996, a total of seven Chinook salmon were captured, while in 1997 only one Chinook salmon was caught (Matern 1996). All Chinook salmon from 1995 and 1996 were captured between January and April and all were identified as fall-run using Frank Fisher's length-at date criteria. Most of these fish were captured with a beach seine in Denverton Slough.

Central Valley 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). In 1982, two steelhead were captured, while only one steelhead was caught in 1985, 1988, 1996, and 1997.

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). Rearing and spawning delta smelt generally inhabit a salinity range of less than two ppt (parts per thousand), although they have been collected at salinities as high as 10 to 14 ppt (DFG 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. In 1994, delta smelt larvae were found primarily in Nurse and Suisun sloughs (Matern et al 1995). In 1995 and 1996 delta smelt larvae were found in all five of the sloughs sampled (Cordelia, Denverton, Nurse, Spring Branch, and Suisun), with the highest numbers occurring in Nurse Slough. During these years, larval fish were generally found March through June. Spawning also occurs in shallow fresh waters of Suisun Bay (Wang 1986).

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). However, studies have indicated that the delta smelt population has decreased over its entire range (Fleming pers. comm.).

Longfin Smelt

Longfin smelt (*Spirinchus thaleichthys*) is designated as a DFG Species of Concern. In California, the largest longfin smelt reproductive population inhabits the San Francisco Bay-Delta estuary (DFG 1992). In the Bay-Delta estuary, the longfin smelt life cycle begins with spawning in the lower Sacramento and San Joaquin rivers, the Delta, and freshwater portions of Suisun Bay (SFEP 1992). The principal nursery habitat for larvae occurs in the productive waters of Suisun and San Pablo bays. Adult longfin smelt are found mainly in Suisun, San Pablo, and San Francisco bays, although their distribution shifts upstream in years of low outflow (Meng et al. 1994). They are also found in local coastal water (Schroeter 2002).

San Francisco Estuary Project (1997) stated that there is a strong relationship between freshwater outflow during the spawning and larval periods and the subsequent abundance of longfin smelt. Outflow disperses buoyant larvae, increasing the likelihood that some will find food. By reducing salinities in Suisun and San Pablo bays, through increased outflow, these areas can provide habitat for larval smelt with few marine or freshwater competitors. The factor most strongly associated with the recent decline in the abundance of longfin smelt has been the increase in water diversions, decreasing outflow, by the SWP and the CVP during the winter and spring months when the smelt are spawning (NHI 1992).

In Suisun, longfin smelt are seasonal residents and rears in large brackish channels. Data from the UC Davis Suisun Marsh Fisheries Monitoring Program indicates that longfin smelt can occur in the Marsh all year. Spawning occurs from November through June throughout the Marsh and in Suisun Bay. Each year of the UC Davis larval fish survey, longfin smelt larval fish were captured in all five sloughs sampled (Suisun, Spring Branch, Nurse, Denverton, and Cordelia) (Matern 1995, 1996, 1997). However, in 1996 the greatest proportion of larval longfin smelt was captured in Cordelia Slough, possibly reflecting the species' preference for more marine conditions (Matern et al 1996). Longfin smelt abundance in the Marsh declined sharply in the early 1980s and has remained low since then (Matern 1996). However, other studies show that there was a population spike in the early 1980s throughout the longfin smelt's range and populations levels in the estuary have decreased to more typical levels since then (Fleming pers. comm.).

Splittail

Splittail (*Pogonichthys macrolepidotus*) is listed as a federal and DFG Species of Concern. The splittail is a large minnow endemic to the Bay-Delta estuary. Once found throughout low elevation lakes and rivers of the Central Valley from Redding to Fresno, this native species is now confined to the lower reaches of the Sacramento and San Joaquin rivers, the Sacramento- San Joaquin Delta, Suisun and Napa marshes, and tributaries of north San Pablo Bay (DFG 1994). Although the splittail is considered a freshwater species, the adults and sub-adults have an unusually high tolerance for saline waters, up to 10 to 18 ppt (Meng 1993). Therefore, the splittail is often considered an estuarine species.

Splittail are a year-round inhabitant of the Marsh and move in and out of large and small dead end sloughs. The Marsh may rarely provide spawning habitat, but generally splittail leave the Marsh to spawn. Splittail are most abundant in late summer in the Marsh when salinities are 6-10 ppt and temperatures 15-23 $^{\circ}$C (Moyle et al 2004). The downstream distribution (including Suisun Marsh) of splittail appears to be affected by salinity, but this may be correlative rather than causative (Moyle et al 2004). Although splittail have been collected at salinities as high as 18 ppt and physiological studies show that splittail have critical salinity maxima of 20 to 29 ppt (Young and Cech 1996), abundance is highest in the 0 to 10 ppt salinity range (Sommer et al forthcoming). Hence, salinity may limit the downstream distribution of splittail during drought.

C-4 SPECIES OF MANAGEMENT CONCERN

Species described in this section are of concern to wetland managers due to their impacts to managed wetlands and wetland management. These species may affect water delivery systems, waterfowl production, or public health.

Mosquito

Mosquitoes are found in temporarily flooded tidal marsh, pannes, heavily vegetated ditches, and brackish seasonal wetlands that comprise a large portion of the Marsh. Sites that drain poorly create habitat that can readily produce large numbers of biting adults. Twenty three mosquito species are found in the Suisun Marsh. Several of these species can carry diseases that affect humans, birds, horses, and canids. The Solano County Mosquito Abatement District conducts continuous monitoring of wetlands in Suisun for mosquito production. Spraying, mosquito fish, larval bait, and water circulation and draining are some of the techniques used to reduce mosquito production.

Mosquitoes and their production are a major concern in the Suisun Marsh due to the proximity of urban development. Adult mosquitoes have been found to travel distances of more than 30 miles (Rees and Nielson 1947) putting many urban areas within the influence of Suisun Marsh mosquito issues. Managed wetlands have the potential to create large populations of mosquitoes, thus, every effort is undertaken to keep water moving to minimize mosquito production.

Properly managed wetlands will have a better chance of controlling mosquito populations. To help reduce mosquito production, several habitat management techniques may be employed including flooding and draining quickly and physical manipulation of mosquito-friendly vegetation (Haffner and Bruce 2004). When management recommendations are followed and a property has the ability to flood and drain quickly (i.e., water control structures are in proper working order, levees are in "good" shape, etc.), aerial mosquito abatement may be avoided thereby reducing the disturbance to local fauna associated with the aerial application of pesticides and reducing the associated abatement costs to the local landowners.

Additional mosquito control and life cycle information may be found at http://ccmvcd.dst.ca.us/mosquitoes.htm

Red fox

It is believed that the red fox is not found in the Suisun Marsh. There is one unconfirmed red fox sighting on Rush Ranch. All surveys since this unconfirmed sighting have been negative. The high number of coyotes in the Marsh may be the reason red fox have been unable to invade Suisun (GIWA staff pers. Comm.).

The red fox could be of great concern for nesting waterfowl if found in the Marsh. Red fox could impact ground-nesting birds in managed wetlands by predating nests and the hens protecting them.

Muskrat

Muskrats are found throughout the Marsh. Impacts to levees by muskrats are ongoing and significant from an operation and maintenance standpoint. They burrow into levees creating weak spots and seepage areas that decrease levee integrity and lead to levee failure. Currently, there is no effort to control muskrat populations in Suisun (GIWA staff pers. comm.).

Beaver

Grizzly Island Wildlife Area biologists have observed an increasing population of beavers in the Marsh. These populations encompass most major ditches that have adjacent ponds such as Grizzly ditch, Pole line, Short cut, and North & South Solano ditches.

Beavers can have significant negative impacts to water delivery systems. Beavers use tules, baccharis, and cattails for dam and den construction in ditches and ponds. They can easily block water control structures overnight with debris thus impacting water delivery or drainage to managed ponds. Removal of dams and debris can be costly. There is no management program for beaver in Suisun (GIWA staff pers. comm.).

Rats

Rats have been captured at several localities in the Marsh. The extent to which rats use the Suisun Marsh is unknown, but they are believed to be found in every habitat throughout the Marsh. Elsewhere, rats are known to prey upon young of waterfowl and eggs as well as the nests and young of other birds (Whisson and Engilis 2001). Too, their extensive burrow systems may impact levee integrity.

No studies or control efforts are currently taking place for rats in Suisun Marsh.

Pigs

See discussion of pig impacts on page (page 84).

Appendix D

Regulatory Restrictions

There are many regulations affecting management of wetlands in Suisun. The most notable regulatory action affecting the Suisun Marsh is the Suisun Marsh Preservation Act passed by the California Legislature in 1977. This Act was created to protect the Suisun marshland and upland habitats from development. An integral part of the Act is the Suisun Marsh Protection Plan, developed by the San Francisco Bay Conservation and Development Commission (BCDC). The plan sets forth policies on a variety of Suisun Marsh issues such as environmental protection, water quality, development, transportation and recreation.

D-1 U.S. ARMY CORPS OF ENGINEERS (USACE)

The USACE provides a Regional General Permit (RGP), administered in part by the Suisun Resource Conservation District (SRCD), which allows maintenance activities such as ditch cleaning, levee coring, and installation of water control structures within the managed wetlands of the Suisun Marsh. The USACE also provides permits for activities that are not covered under the RGP.

The current RGP (Amendment Three) authorizes landowners to conduct approved work activities and place fill in wetlands subject to USACE jurisdiction. This permit limits the time of year work can be done, how much work (volume) can be done, when/how much water may be taken into a property, what may be done with excavated native material, where riprap can be placed for bank protection, the installation of new flood structures, and also places twelve additional conditions (see page 5 of RGP #3) on the ability of landowners to work on their properties in the Marsh. It also requires the SRCD to administer a gate-monitoring program during fish closures required by NMFS/NOAA.

Although volume restrictions are fairly liberal, there are times when they prevent landowners from doing all the work they need to do in a given work season. Below is a list of RGP #3 restrictions and how they affect landowner management strategies in the Marsh:

4) <u>Work in interior ditches</u> includes excavation from existing primary, secondary, and spreader V-ditches ditches or excavation to create new primary, secondary, and spreader V-ditches. Annual excavation volumes are limited; therefore landowners often must clean ditches on a rotational basis. This can add to the cost of equipment mobilization. Excavated material must be side cast and used for an authorized activity, or removed to an area outside of USACE jurisdiction (also adds cost).

5) <u>Work on levees</u> includes the placement of approved materials on the crown or sides of interior levees and the crown or landward side of exterior levees. Annual material placement volumes are limited; therefore landowners often must repair levees on a rotational basis. In emergency cases (levee blowout) special permission must be granted by the USACE to exceed volume limitations. Delays in USACE approval allow damage to progress and therefore increase repair costs to the landowner.

Also included in this category are levee coring (generally not necessary in large volumes), road maintenance (usually the 5,000 cubic yard limit is adequate), and replacement of riprap. Riprap must be approved material and may only be placed where riprap had previously existed. This restriction is especially onerous because without riprap (or an alternate method of bank protection) many levee maintenance problems cannot be adequately addressed and remain a perpetual problem (adding to costs for landowners).

6) Work in managed wetlands includes grading, discing, installation of pumps, creation of waterfowl nesting islands, and the relocation, replacement, or installation of new duck blinds. Annual grading volumes are limited; therefore landowners may have to grade ponds on a rotational basis. This can add to the cost of equipment mobilization. Graded material may not be stockpiled, so in emergency cases (levee blowout) material must be dredged from adjacent sloughs and special permission must be granted by the USACE to dredge. Delays in USACE approval allow damage to progress and therefore increase repair costs to the landowner.

   Discing acreage is not limited by RGP #3 but landowners observe a voluntary annual discing limit of 20% of their total ownership due to endangered species (SMHM) concerns. This voluntary limit imposes the need for rotational discing that may slow the recovery of poorly managed wetlands and can add to the cost of equipment mobilization. Volume limitations generally do not hamper the creation of nesting islands. Limitations on blind work can slow progress on the development/improvement of a hunting program and can add to the cost of equipment mobilization.

7) Water control structure work is limited to replacement/maintenance of like structures (including bulkheads), installation of new drain structures/accompanying bulkheads, and maintenance of existing structures. 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).

D-2 U.S. FISH AND WILDLIFE SERVICE (USFWS) AND NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION FISHERIES (NOAA FISHERIES)

The USFWS and NOAA are charged with enforcement of the Federal Endangered Species Act (ESA). Through Section 7 of the ESA these agencies issue biological opinions of projects that may include conditions to protect species covered by the ESA.

In Suisun Marsh the USFWS and NOAA have mandated restrictions on the timing and location of maintenance activities and diversions through biological opinions issued on the RGP. Diversion restrictions are a condition of the biological opinion issued by NOAA for the protection of delta smelt and migrating salmon (Figures 12, 13, and 14). Landowners diverting water for marsh management may use no more than 25% of their water control structures diversion capacity from 11/1 to the last day of waterfowl season and no more than 35% from 4/1 to 5/31. There is a total closure of water diversions in specified sloughs from 2/21 to 3/31.

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.

D-3 U.S. DEPARTMENT OF AGRICULTURE (USDA)

The USDA is a federal agency that provides a Pesticide Applicators Permit to SRCD and regulates herbicide use by landowners under this permit. The permit enables landowners to manage and manipulate vegetation using herbicides.

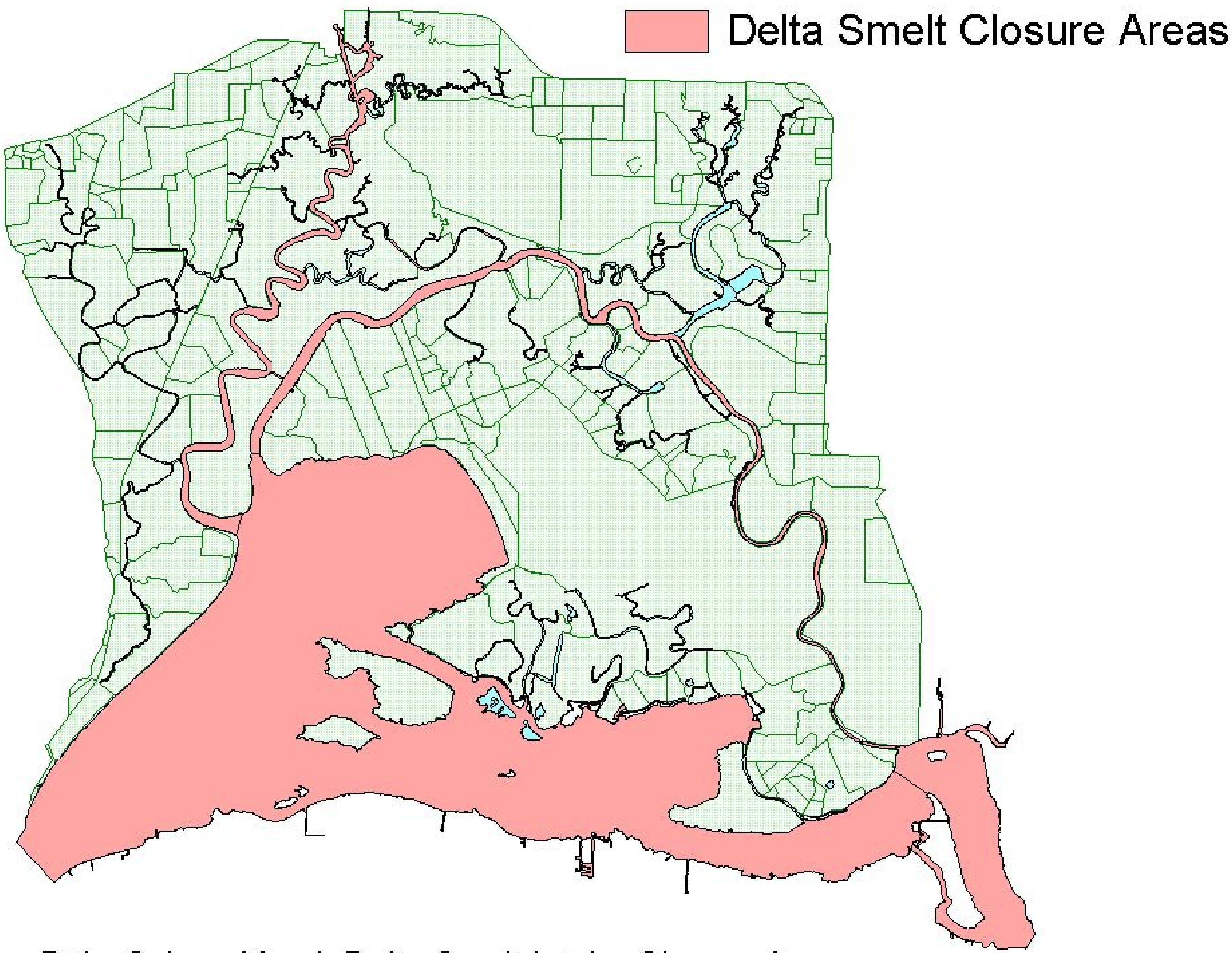


Figure D-1. Suisun Marsh Delta Smelt Intake Closure Areas.

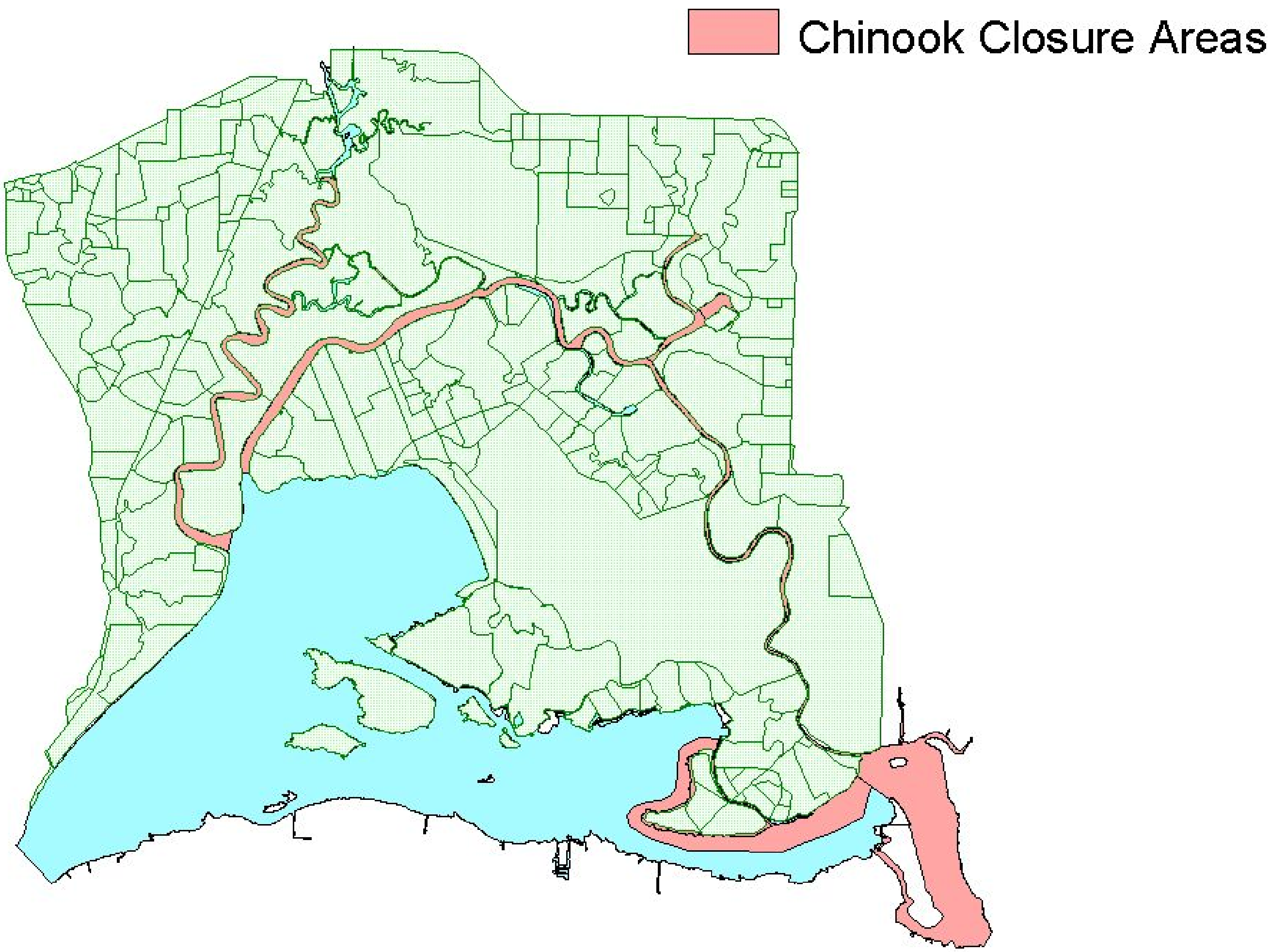


Figure D-2. Suisun Marsh Chinook Salmon Intake Closure Areas.

D-4 SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD (RWQCB)

The RWQCB is a local board of the State Water Resources Control Board that protects and enhances water quality. Under section 401 of the Clean Water Act, this agency must issue a Water Quality Certification for the activities covered by RGP #3. This certification says Marsh activities will not cause water discharges that violate State water quality standards. The RWQCB has also issued a Waiver of Waste Discharge Requirements under the RGP #3.

Landowners must also obtain concurrence from RWQCB prior to importing material into the Marsh. This process has been very long and time-consuming in the past making it more convenient for landowners to use pond substrate or dredge materials for maintenance and repair activities

D-5 CALIFORNIA DEPARTMENT OF FISH AND GAME (DFG)

DFG is a State agency that provides streambed alteration agreements through sections 1600 and 1601 of the DFG Code for projects and activities that would disturb river or stream habitats.

The DFG is also the State agency charged with enforcement of the California Endangered Species Act and the Native Plant Protection Act to protect and preserve threatened and endangered species. For managed wetland owners in Suisun Marsh this means that any work done in listed species habitat must be surveyed for listed species. For example, any work in tidal areas (pipe installation or bulkhead construction) requires a site inspection prior to starting work. If threatened or endangered plants are present, the DFG inspector will make recommendations to avoid or minimize impacts.

D-6 BAY AREA AIR QUALITY MANAGEMENT DISTRICT (BAAQMD)

The BAAQMD is a district of the State Air Resources Board that works with the local DFG and fire districts to provide marsh burn permits that specify the timing and acreage of a burn as well as other fire procedures. For managers, marshland burning may be the best tool for setting back vegetation succession, as it is inexpensive, quick, and efficient. In the past, fewer permits have been approved than are needed to use burning as an effective marsh management tool. Burning restrictions have retarded marsh management efforts in the Suisun Marsh.

D-7 SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION (BCDC)

BCDC is a State agency that developed, and currently upholds, the Suisun Marsh Protection Plan policies as outlined by the Suisun Marsh Preservation Act of 1977. BCDC has jurisdiction over the Primary Suisun Marsh as well as the Secondary Marsh that includes uplands adjacent to the Primary Marsh area. BCDC permits are issued for projects and maintenance activities in the Suisun Marsh. (Potrero Hill Landfill Expansion Project Draft EIR)

The BCDC must approve individual landowner management plans, written as directed by the SMPA/SMPP, prior to their implementation. In addition to approval of landowner management plans, BCDC requires landowner to obtain permits for projects and other maintenance activities. The cost of these permits varies according to the type/size of the project. The BCDC restricts work subject to their authority from April 15 through October 1.

BCDC permitting issues generally do not hinder landowner marsh management. Permitting issues are mostly related to gas wells development and new building construction.

D-8 CALIFORNIA STATE LANDS COMMISSION (CSLC)

CSLC is a State agency that upholds the policies of the Suisun Marsh Protection Plan and other State resource policies when reviewing or preparing environmental documents for proposed projects. The State Lands Commission has the primary responsibility for carrying out the management recommendations in the SMPP on lands owned by the State and does not directly affect private lands.

D-9 SOLANO COUNTY DEPARTMENT OF ENVIRONMENTAL MANAGEMENT (DEM)

The DEM is a local agency that has policies similar to that of the Suisun Marsh Protection Plan, but also specifies land use details on a parcel scale. DEM regulations do not generally affect landowners in the Marsh.

D-10 SOLANO COUNTY MOSQUITO ABATEMENT DISTRICT (SCMAD)

The SCMAD is a local agency responsible for the control of mosquitoes in Suisun Marsh through the use of chemicals and encouraging beneficial water management. The SCMAD is not a permitting agency but more of a policing agency. They are responsible for detecting mosquito production sites and treating them to prevent mosquito-vectored diseases.

Costs to landowners for mosquito control (aerial spraying after fall flood) can be substantial. Some of the regulatory restrictions discussed above have hurt the landowner’s ability to control mosquito production on their properties. For example, burning and discing salt grass is effective for mosquito control but these activities may be restricted by regulation. A fast flood followed by a fast drain may decrease mosquito production but activities that decrease flood time (adding flood structures, cleaning ditches, making new ditches, and building new interior levees) are restricted or prohibited.

Appendix E

Mechanical Vegetation Management and Manipulation

E-1 Planting

Land managers plant seeds to change or enhance habitat characteristics for forage, cover, or nesting. Seeding occurs in both managed upland and wetland areas.

On wetland areas, moist soil vegetation should include at least three major species for a minimum of 25% of the total seasonal wetland acreage (DFG 1994). As an example, swamp timothy (*Crypsis schoenoides*), watergrass (*Echinochloa crusgalli*) and smartweed (*Polygonum* spp.) can be encouraged. These are representative of low salt-tolerant plants. A manager must know the specific local growing conditions in order to determine which plants to encourage.

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.

> Seeding for waterfowl may include such species as brass buttons (*Cotula coronopifolia*), fat hen (*Atriplex triangularis*), swamp timothy, smartweed, and watergrass in wetlands (DFG 2000). Although present in the seed bank, additional watergrass seed may be applied to enhance growth and spread of watergrass. However, Rollins (1981) suggests that no more than 25% of the area of a duck club be planted in watergrass, because it is expensive and does not provide enough habitat variation.
>
> To promote waterfowl and pheasant nesting cover, uplands may be disced and seeded in annual ryegrass (*Lolium multiflorum*), the annual or biennial vetch (*Vicia* spp.), or perennials such as tall wheatgrass (*Elytrigia* spp.) and Harding grass (*Phalaris* spp.). In many areas where they have been planted previously, these species continue to grow with minimal manipulation. Barley (*Hordeum* spp.) may be planted to promote adult pheasant foraging areas. In brood foraging areas, clovers and broadleaves may be planted if they have not established themselves previously from the existing seed bank. Plants from the seed bank, such as fat hen and bird's-foot trefoil (*Lotus corniculatus*), should be encouraged through the proper water management schedule (DFG 2002, 2003b).

Alkali bulrush (*Scirpus maritimus*) may be planted in wetlands. However, the Suisun Resource Conservation District (SRCD) generally recommends providing the appropriate conditions to favor this plant, such as adjusting the water regime, since the seeds are already present in the soil.

E-2 Invasive plant species control

Both native and non-native plants can be considered invasive, depending upon the desired habitat. Non-native invasives 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.

One of the most problematic non-natives in Suisun Marsh is perennial pepperweed (*Lepidium latifolium*). Pepperweed invades both upland and wetland areas, including tidal zones where spraying is generally not permitted. SRCD has reported limited success using Roundup® (glyphosate) to control pepperweed populations. In spring to early summer, plants are mowed, sprayed, disced, and then sprayed again. Discing is recommended only after spraying.

Two other perennial non-native invasives on managed wetlands in Suisun are pampas grass (*Cortaderia selloana*) and *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 resprouting. 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.

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).

There are also annual non-native invasive species on Suisun managed wetlands, such as cocklebur (*Xanthium strumarium*) and bristly ox-tongue (*Picris echioides*). One method for controlling these species is to flood managed ponds to capacity for six weeks or more (DFG 2003a).

E-3 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 invasives. 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 can allow the undesirable plants to rebound, in some cases stronger than before.

The Bay Area Air Quality Management District (BAAQMD) allows for controlled burns in the Suisun Marsh during the spring and fall. In the spring, burning typically occurs from February 1st to March 31st and can be extended by the BAAQMD. In the fall, burning generally occurs from September 1st to October 15th. All marsh management fires must be certified by the California Department of Fish and Game and require a Smoke Management Plan (SMP) 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.

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 (when it is attached to other plant parts), 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 zones (SRCD 1998).

E-4 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).

Cross discing is considered the most effective discing technique. 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 give them the competitive advantage needed to completely take over. 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 on a regular basis can cause 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 comes in contact with water.

Brass buttons and fat hen will readily grow where saltgrass has been disced. Ponds managed for brass buttons and fat hen can be disced every 4-5 years between July-September (just before fall flooding) to remove plant litter, improve seed production, and remove undesirable plants (Rollins 1981).

As stated earlier, permanent ponds can be drained once every five years, followed by burning or discing where cattails and tules have become dense. The ponds should then be disced or mowed in mid-summer when new growth is two feet high (Rollins 1981).

To encourage pheasant habitat, appropriate areas are disced annually to improve the brood foraging areas and create open rooster crowing areas. Discing and properly irrigating tends to encourage broadleaved plants instead of grasses. The broadleaved plants support invertebrates for pheasant chicks and provide better cover from predators. Disced areas can also create breaks in the vegetation for hunters to push birds out in the open, allowing for enhanced hunting opportunities. For pheasant habitat enhancement, discing should take place in October before the first rain (DFG 2002, 2003b).

Discing is voluntarily limited to one fifth of a property per year (SRCD 1998).

E-5 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.

Alkali bulrush, though desirable as a waterfowl plant, can become so dense as to prevent access by birds (Rollins 1981). When this happens, mowing is an effective control measure.

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.

Appendix F

Chemical Reactions Forming Red Water

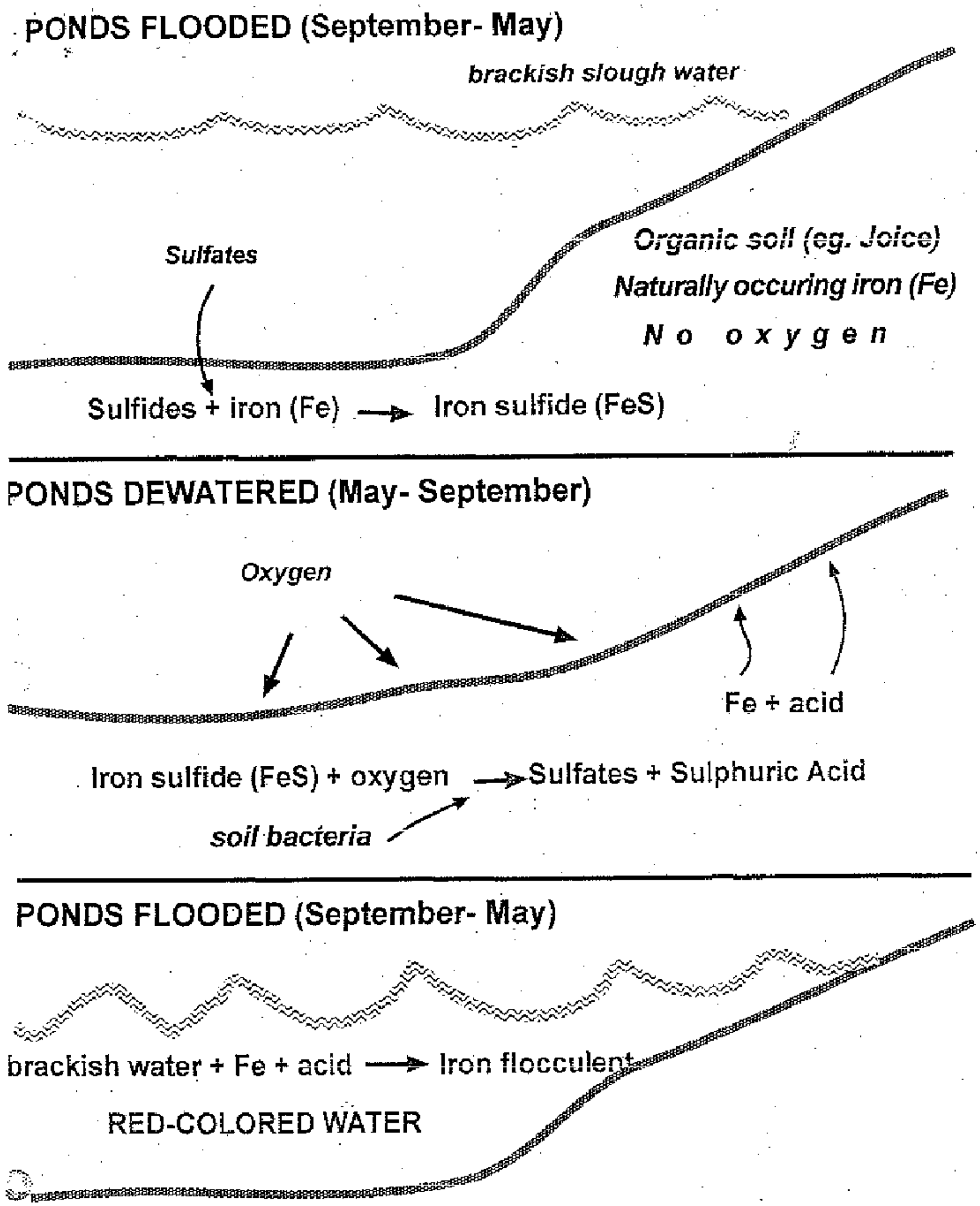


Illustration describing the chemical reactions that result in the formation of red water. (USGS 1999)

Appendix G

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Appendix E

Essential Fish Habitat Assessment and
Biological Opinion for the Regional General Permit #3
(File Number: 24215N) Extension

PREPARED BY,
SUISUN RESOURCE CONSERVATION DISTRICT
AND
CALIFORNIA DEPARTMENT OF FISH AND GAME
CENTRAL VALLEY BAY-DELTA BRANCH

Appendix A, Page 1 of 10. BDAT query results for starry flounder in Suisun Marsh.								
Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/10/1980	12:00:00	Otter Trawl	Starry Flounder	1	38
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	2/24/1981	11:14:00	Otter Trawl	Starry Flounder	1	91
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/6/1980		Townet Survey	Starry Flounder	1	39
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	9/17/1980	12:00:00	Otter Trawl	Starry Flounder	1	63
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/9/1998	10:19:00	Otter Trawl	Starry Flounder	1	252
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/17/1988	14:08:00	Otter Trawl	Starry Flounder	1	172
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	6/25/1973		Townet Survey	Starry Flounder	1	31
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/8/1969		Townet Survey	Starry Flounder	1	
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	4/25/1997	11:29:00	Otter Trawl	Starry Flounder	1	20
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/10/1980	12:00:00	Otter Trawl	Starry Flounder	1	29
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	7/24/1997	11:29:00	Otter Trawl	Starry Flounder	1	48

Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/29/1978		Townet Survey	Starry Flounder	1	41
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	56
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	11/17/1997	8:33:00	Otter Trawl	Starry Flounder	1	237
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/11/1996	7:31:00	Townet Survey	Starry Flounder	1	38
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	6/12/1996	11:36:00	Otter Trawl	Starry Flounder	1	30
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	3/25/1997	9:50:00	Otter Trawl	Starry Flounder	1	97
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/6/1980		Townet Survey	Starry Flounder	1	31
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	51

Appendix A, Page 2. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	10/13/1994	10:05:00	Otter Trawl	Starry Flounder	1	65
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	8/5/1980	11:10:00	Otter Trawl	Starry Flounder	1	53
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	10/7/1981	13:56:00	Otter Trawl	Starry Flounder	1	81
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	43
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	6/24/1980	19:40:00	Otter Trawl	Starry Flounder	1	29

Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/17/1988	14:08:00	Otter Trawl	Starry Flounder	1	180
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	4/27/1989	12:41:00	Otter Trawl	Starry Flounder	1	27
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	12/4/1980	15:30:00	Otter Trawl	Starry Flounder	1	96
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	5/30/1986	14:18:00	Otter Trawl	Starry Flounder	1	21
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	2/24/1981	11:14:00	Otter Trawl	Starry Flounder	1	75
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	3/28/1984	14:58:00	Otter Trawl	Starry Flounder	1	105
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/23/1983	10:33:00	Otter Trawl	Starry Flounder	1	126
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	6/25/1973		Townet Survey	Starry Flounder	1	42
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	5/28/1980	13:35:00	Otter Trawl	Starry Flounder	1	23
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	8/19/1985	14:36:00	Otter Trawl	Starry Flounder	1	56
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/15/1997	11:34:00	Otter Trawl	Starry Flounder	1	242
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	6/26/1986	16:01:00	Otter Trawl	Starry Flounder	1	40
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/15/1990	7:20:00	Townet Survey	Starry Flounder	1	59

Appendix A, Page 3. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	5/30/1986	14:18:00	Otter Trawl	Starry Flounder	1	18

Monitoring								
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/10/1980	12:00:00	Otter Trawl	Starry Flounder	1	40
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	2/24/1981	11:14:00	Otter Trawl	Starry Flounder	1	121
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/16/1996	9:48:00	Otter Trawl	Starry Flounder	1	240
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/9/1982	14:35:00	Otter Trawl	Starry Flounder	1	34
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	8/19/1980	16:25:00	Otter Trawl	Starry Flounder	1	44
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	7/8/1980	16:45:00	Otter Trawl	Starry Flounder	1	32
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	7/22/1980	10:50:00	Otter Trawl	Starry Flounder	1	48
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/30/1963		Townet Survey	Starry Flounder	1	
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	7/20/1998	6:42:00	Townet Survey	Starry Flounder	1	71
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/30/1986		Townet Survey	Starry Flounder	1	40
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	4/27/1989	12:41:00	Otter Trawl	Starry Flounder	1	23
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	7/6/1980		Townet Survey	Starry Flounder	1	39
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	6/29/1978		Townet Survey	Starry Flounder	1	43

Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	7/8/1969		Townet Survey	Starry Flounder	1	
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	9/30/1980	13:31:00	Otter Trawl	Starry Flounder	1	61
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/9/1982	14:35:00	Otter Trawl	Starry Flounder	1	39
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	4/25/1997	8:45:00	Otter Trawl	Starry Flounder	1	28
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	11/16/1998	11:30:00	Otter Trawl	Starry Flounder	1	227

Appendix A, Page 4. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Fall Midwater Trawl	608MWT	MONTEZUMA SL., AT E END AT ROARING RIVER SLOUGH	9/12/1986	10:20:00	Midwater Trawl	Starry Flounder	1	69
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/22/1984	11:41:00	Otter Trawl	Starry Flounder	1	32
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/10/1980	11:15:00	Otter Trawl	Starry Flounder	1	23
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	6/29/1978		Townet Survey	Starry Flounder	1	23
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/17/1980	10:40:00	Otter Trawl	Starry Flounder	1	59
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	6/21/1972		Townet Survey	Starry Flounder	1	
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	7/8/1980	16:45:00	Otter Trawl	Starry Flounder	1	39
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	6/12/1996	11:36:00	Otter Trawl	Starry Flounder	1	25

Monitoring								
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/24/1981	12:25:00	Otter Trawl	Starry Flounder	1	84
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/21/2003	15:10:00	Otter Trawl	Starry Flounder	1	228
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/29/1978		Townet Survey	Starry Flounder	1	41
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	3/23/2000	11:06:00	Otter Trawl	Starry Flounder	1	132
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	6/24/1980	19:40:00	Otter Trawl	Starry Flounder	1	24
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/17/1980	11:05:00	Otter Trawl	Starry Flounder	1	61
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/9/1998	10:19:00	Otter Trawl	Starry Flounder	1	247
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	8/19/1980	15:35:00	Otter Trawl	Starry Flounder	1	45
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	3/23/2000	11:06:00	Otter Trawl	Starry Flounder	1	165
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	7/24/1997	11:29:00	Otter Trawl	Starry Flounder	1	53

Appendix A, Page 5. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	7/22/1980	16:00:00	Otter Trawl	Starry Flounder	1	41
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/27/1986	11:19:00	Otter Trawl	Starry Flounder	1	132
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	7/19/1991	12:27:00	Otter Trawl	Starry Flounder	1	59

Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	7/6/1980		Townet Survey	Starry Flounder	1	41
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	39
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	10/15/1982	15:25:00	Otter Trawl	Starry Flounder	1	93
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/22/1984	11:41:00	Otter Trawl	Starry Flounder	1	31
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	4/22/1987	10:13:00	Otter Trawl	Starry Flounder	1	118
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/5/1980	9:03:00	Otter Trawl	Starry Flounder	1	43
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/18/1999	13:15:00	Otter Trawl	Starry Flounder	1	234
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	7/22/1980	15:00:00	Otter Trawl	Starry Flounder	1	50
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	6/30/1988	10:48:00	Otter Trawl	Starry Flounder	1	75
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	3/27/1995	14:30:00	Otter Trawl	Starry Flounder	1	126
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/9/1998	10:19:00	Otter Trawl	Starry Flounder	1	228
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	12/14/1994	13:05:00	Otter Trawl	Starry Flounder	1	97
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	50
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	2/24/1981	13:27:00	Otter Trawl	Starry Flounder	1	102

Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	7/1/1971		Townet Survey	Starry Flounder	1	

Appendix A, Page 6. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/9/1998	10:19:00	Otter Trawl	Starry Flounder	1	105
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	8/5/1980	11:10:00	Otter Trawl	Starry Flounder	1	37
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	7/22/1980	16:00:00	Otter Trawl	Starry Flounder	2	40
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	6/10/1980	10:10:00	Otter Trawl	Starry Flounder	1	26
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/28/1970		Townet Survey	Starry Flounder	1	
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/16/1964		Townet Survey	Starry Flounder	1	
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	12/16/1980	11:00:00	Otter Trawl	Starry Flounder	1	52
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/29/1978		Townet Survey	Starry Flounder	1	36
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	40
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/9/1998	10:19:00	Otter Trawl	Starry Flounder	1	190
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	2	61
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/10/1980	12:00:00	Otter Trawl	Starry Flounder	1	25
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	8/19/1980	16:25:00	Otter Trawl	Starry Flounder	1	56

Monitoring								
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	6/25/1973		Townet Survey	Starry Flounder	1	22
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	9/24/1996	13:36:00	Otter Trawl	Starry Flounder	1	235
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	7/19/1993	10:27:00	Otter Trawl	Starry Flounder	1	40
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	7/22/1980	10:50:00	Otter Trawl	Starry Flounder	1	39
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	2/26/1997	12:11:00	Otter Trawl	Starry Flounder	1	110
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	3/30/1989	10:28:00	Otter Trawl	Starry Flounder	1	93

Appendix A, Page 7. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	12/4/1980	15:30:00	Otter Trawl	Starry Flounder	1	103
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/8/1961		Townet Survey	Starry Flounder	1	
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	55
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	9/5/1980	10:15:00	Otter Trawl	Starry Flounder	1	92
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/10/1980	11:15:00	Otter Trawl	Starry Flounder	1	25
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	12/22/1982	10:23:00	Otter Trawl	Starry Flounder	1	86
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	9/30/1980	13:31:00	Otter Trawl	Starry Flounder	1	52

Monitoring								
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	1/7/1999	9:09:00	Otter Trawl	Starry Flounder	1	224
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	60
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/21/2003	15:10:00	Otter Trawl	Starry Flounder	1	140
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/5/1980	9:03:00	Otter Trawl	Starry Flounder	1	78
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	1/30/1997	10:57:00	Otter Trawl	Starry Flounder	1	79
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	7/22/1980	10:50:00	Otter Trawl	Starry Flounder	1	37
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/22/1984	11:41:00	Otter Trawl	Starry Flounder	2	37
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/5/1980	9:03:00	Otter Trawl	Starry Flounder	2	82
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	5/30/1986	14:18:00	Otter Trawl	Starry Flounder	1	30
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	9/19/1985	10:07:00	Otter Trawl	Starry Flounder	1	90
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/23/1987	12:46:00	Otter Trawl	Starry Flounder	1	214

Appendix A, Page 8. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/16/1994	8:30:00	Townet Survey	Starry Flounder	1	62
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	12/14/1994	13:05:00	Otter Trawl	Starry Flounder	1	115

Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/10/1980	12:00:00	Otter Trawl	Starry Flounder	1	26
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	5/12/1999	14:25:00	Otter Trawl	Starry Flounder	1	33
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	4/15/1999	10:11:00	Otter Trawl	Starry Flounder	1	148
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	11/16/1998	14:27:00	Otter Trawl	Starry Flounder	1	100
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/4/1980	18:45:00	Otter Trawl	Starry Flounder	1	54
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/20/1995	7:37:00	Townet Survey	Starry Flounder	1	62
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	7/8/1980	16:45:00	Otter Trawl	Starry Flounder	1	42
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/29/1978		Townet Survey	Starry Flounder	1	37
Suisun Marsh Fisheries Monitoring	WL1	Wells Slough - upper	5/16/1979	11:35:00	Otter Trawl	Starry Flounder	1	20
Suisun Marsh Fisheries Monitoring	DV4	Denverton Slough - upper	5/6/1981	12:27:00	Otter Trawl	Starry Flounder	1	85
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	11/17/1997	8:33:00	Otter Trawl	Starry Flounder	1	252
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	5/22/1997	9:59:00	Otter Trawl	Starry Flounder	1	49
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	5/30/1986	14:18:00	Otter Trawl	Starry Flounder	1	26
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/5/1980	9:03:00	Otter Trawl	Starry Flounder	2	41
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	7/6/1980		Townet Survey	Starry Flounder	1	33

Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	4/21/1981	13:24:00	Otter Trawl	Starry Flounder	1	101
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/12/1996	12:01:00	Otter Trawl	Starry Flounder	1	29

Appendix A, Page 9. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	7/15/1990	7:20:00	Townet Survey	Starry Flounder	1	85
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	3/20/1998	9:48:00	Otter Trawl	Starry Flounder	1	83
Summer Townet Survey	609TNS	Montezuma Slough at Nurse Slough	6/29/1978		Townet Survey	Starry Flounder	1	28
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	12/9/1998	10:19:00	Otter Trawl	Starry Flounder	2	226
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	7/24/1997	11:29:00	Otter Trawl	Starry Flounder	1	56
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/10/1980	12:00:00	Otter Trawl	Starry Flounder	1	19
Summer Townet Survey	610TNS	Montezuma Slough at road from Bird's Landing	7/6/1980		Townet Survey	Starry Flounder	1	40
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/22/1984	11:41:00	Otter Trawl	Starry Flounder	1	35
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	5/30/1986	14:18:00	Otter Trawl	Starry Flounder	2	22
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	5/16/1990	13:50:00	Otter Trawl	Starry Flounder	1	33
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	5/5/1981	14:02:00	Otter Trawl	Starry Flounder	1	114
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	6/24/1980	19:40:00	Otter Trawl	Starry Flounder	1	28

Monitoring								
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	7/22/1980	16:00:00	Otter Trawl	Starry Flounder	1	34
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	9/30/1980	13:31:00	Otter Trawl	Starry Flounder	1	75
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	6/24/1980	19:40:00	Otter Trawl	Starry Flounder	1	33
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	9/5/1980	9:03:00	Otter Trawl	Starry Flounder	1	45
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	4/28/1981	16:34:00	Otter Trawl	Starry Flounder	1	97
Suisun Marsh Fisheries Monitoring	GY1	Goodyear Slough - upper	6/24/1980	18:57:00	Otter Trawl	Starry Flounder	1	34
Suisun Marsh Fisheries Monitoring	SU2	Suisun Slough - below Boynton Slough	2/11/1981	10:22:00	Otter Trawl	Starry Flounder	1	70

Appendix A, Page 10. BDAT query results for starry flounder in Suisun Marsh.

Project	Station Code	Station Name	Sample Date	Sample Time	Survey Type	Common Name	Count	Length (mm)
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	8/5/1980	11:10:00	Otter Trawl	Starry Flounder	1	46
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	2/25/2000	13:30:00	Otter Trawl	Starry Flounder	1	143
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	3/25/1997	9:50:00	Otter Trawl	Starry Flounder	1	175
Suisun Marsh Fisheries Monitoring	GY3	Goodyear Slough - lower	1/30/1997	10:57:00	Otter Trawl	Starry Flounder	1	268

EFH Assessment and Biological Assessment for RGP #3 Extension

INTRODUCTION

This document presents the findings of the Essential Fish Habitat (EFH) assessment and a biological assessment conducted by the Suisun Resource Conservation District (SRCD) and the California Department of Fish and Game (CDFG) for the proposed extension of US Army Corps of Engineers (USACE) Regional General Permit 3 (RGP) (File Number 24215N). The Magnuson-Stevens Fishery Conservation and Management Act of 1976 and the Section 7 of the Federal Endangered Species Act require this assessment. This assessment describes how wetland habitat management actions in the diked, seasonal wetlands of the Suisun Marsh may affect EFH species, EFH habitats, and endangered fish species within the Suisun Marsh.

BACKGROUND

Since 1977, the SRCD and the CDFG have jointly held a Regional General Permit (RGP) that allows maintenance activities within the primary management area of the Suisun Marsh. Each of the past four RGP renewals has been issued for five-year periods. Breaking with this pattern, the SRCD and the CDFG are seeking a two-year extension for the current RGP at which time the Management, Preservation, and Restoration Plan for the Suisun Marsh (Plan) should be completed. The Plan objectives will be supported with the development of a programmatic EIS/EIR (PEIR/PEIS), which will contain certain project-specific activities such as the RGP 3 renewal and will be described and analyzed at a high level of detail. Depending on the outcome of the PEIR/PEIS alternative development, the renewed RGP may be significantly different and include new activities such as dredging from tidal sloughs for levee maintenance and have new applicants California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Bureau) for the maintenance of their facilities in the Marsh. This two-year extension will allow for the continued operation and maintenance of existing facilities while waiting for the Plan to be completed. Project sites where maintenance activities are conducted in the Suisun Marsh are located within an area identified as EFH for various life stages of fish species federally managed under the Pacific Groundfish Fishery Management Plan, the Pacific Coast Salmon Fishery Management Plan, the Coastal Pelagics Fishery Management Plan, and other areas which are seasonal habitat for several listed salmon and steelhead species. Most of the maintenance activities conducted under the current RGP 3 are conducted in a manner that cause only temporary impacts and are not likely to affect EFH or listed species. However, the operation and maintenance of some water control structures may affect EFH for listed species due to the potential for entrainment of aquatic organisms with the diversion of water into interior ponds. Seasonal water diversion restrictions, measures to reduce entrainment of listed fish species (Best Management Practices), and water diversion screenings are already in place to minimize impacts. There are twenty-one approved work activities in the current RGP that will be evaluated in this assessment to determine which have no effect, which are not likely to adversely affect ESA listed fish species and result in no more than minimal and

temporary adverse effects to EFH, and which may affect ESA listed species or have adverse affects to EFH. The effects of two additional proposed activities that are not in the current RGP are also evaluated herein for consideration for issuance if USACE nation wide permits.
The Suisun Marsh, about 35 miles northeast of San Francisco in southern Solano County, provides habitat for numerous species of plants, fish, and wildlife. Historically, the Suisun Marsh was comprised of a wide plain of saltgrass (*Distichlis spicata*) associations supporting a large number of brackish (halophytic) marsh plant species and included about 68,000 acres of tidal wetlands. From the mid-1880s to the early 1900s, over 90 percent of these wetlands were reclaimed for agriculture. Agricultural production and success was limited due to increased salinity in the Suisun Bay/Marsh region. Most of the levees originally constructed for agricultural reclamation now form part of the infrastructure for managing water levels in seasonal non-tidal (managed) wetlands. Suisun's levee and water control infrastructure has been used to create seasonal wetland habitat since the 1940's. Today, ninety percent of the wetlands in the Suisun Marsh are diked and managed as food, cover, and nesting habitat for wildlife. Seasonal wetland management strategies in the Suisun Marsh are based on waterfowl food habits studies conducted in the Suisun Marsh during the late 1960's and early 1970's. One study (George 1965) indicated that seeds from alkali bulrush (*Scirpus maritimus*), fat hen (*Atriplex triangularis*), and brass buttons (*Cotula coronopifolia*) provided the bulk of the wintering waterfowl food supply. This study was the basis for future studies (Mall 1969; Rollins 1973) of habitat conditions necessary to produce the above seed bearing plants. These studies concluded that plant communities in the Suisun Marsh are controlled primarily by the depth and duration of soil submergence and secondarily by the concentration of salts in the root zone.

In the early 1980's the Soil Conservation Service prepared management plans for each of the 160 privately managed wetlands in the Suisun Marsh. These plans recommended leaching soil salts from the root zone by performing one or more leach cycles (rapidly flooding and draining the wetlands to one foot below pond bottom). These water management schedules recommended rigid dates for water application, drainage, and water levels within the managed ponds but cannot be effectively implemented due to changes in environmental, regulatory, physical, or management constraints.

The National Oceanic Atmospheric Administration (NOAA) and the United States Fish and Wildlife Service (USFWS) have imposed water diversion restrictions on most unscreened diversions in the Suisun Marsh to avoid adverse impacts to Delta smelt (*Hypomesus transpacificus*), winter-run Chinook salmon (*Oncorhynchus tshawytscha*), and other listed resident and anadromous fish species. Therefore, implementing these water management schedules for effective maintenance of soil salinities may not occur on properties with these diversion restrictions in place unless a fish screen has been installed.

For managed wetlands in Suisun Marsh, wetland managers must take into account factors such as soil water salinities, depth and duration of soil submergence, and applied water salinity to prevent the accumulation of soil salinities above natural levels outlined by the United States Department of Agriculture (USDA) Soil Conservation Service (1977) for

Suisun Marsh soils. Most wetland managers in the Suisun Marsh begin flooding the wetlands in early October in preparation for the fall migration of waterfowl, the waterfowl-hunting season, and to reduce mosquito production in the Marsh. They then maintain stable water levels through the winter, drain in early spring and fluctuate water levels until mid summer.

ENVIRONMENTAL SETTING

Suisun Marsh is in southern Solano County, California, west of the Sacramento-San Joaquin Delta and north of Suisun Bay. This tidally influenced marsh is a vital wintering and nesting area for waterfowl of the Pacific Flyway and it represents about 12 percent of California's remaining wetland habitat.

Topography

Suisun Marsh lies near the Sacramento Valley within a large notch in the Coast Range and occupies a relatively narrow and broken plain north of Suisun Bay. From Suisun Bay, water from the Central Valley drains through Carquinez Strait into San Francisco Bay. Networks of tidal sloughs, principally tributaries of Suisun and Montezuma sloughs, crosshatch the marshland. A system of levees encloses about 90 percent of the marshland. Levees range from 4-8 feet above ground level and most of the wetlands are at or below mean tide elevation. Hills rising to 1,100 feet above sea level surround the Marsh to the north and west. To the east, the Potrero and Montezuma Hills rise 300-400 feet above the Marsh.

Geology

Suisun Marsh is geologically young, formed during the late-Pliocene and Pleistocene periods (Miller *et al.* 1975). In its present geologic form, the Marsh is an extension of San Francisco Bay with features of the Central Valley. In the late Miocene and early Pliocene, the area that is now the Central Valley was a shallow sea. Successive uplifts and gradations slowly raised the fault blocks of the west ranges and isolated the Central Valley. At the end of the Pliocene, a major orogeny formed the Coast Ranges. The sea receded and interior and internal folding which occurred among the younger sediments of the region (Miller *et al.* 1975). During the early Pleistocene, a time of erosion and gradation, drainage of the Central Valley escaped to the Pacific Ocean much the same way as it does now.

Mountain building laid the framework for the current landscape in the mid-Pleistocene. In the immediate vicinity of San Francisco Bay, block faulting took place on a large scale, outlining the trough of the bay that was flooded by the ocean. The Sacramento and San Joaquin rivers, however, maintained their courses to the ocean across these rising blocks, down-cutting narrowly in the faults of the North Bay and creating Carquinez Strait (Miller *et al.* 1975). During this period the down-folding of the underlying Cretaceous beds east of the Coast Ranges occurred. This basin developed a gentle subsidence in the bay and coastal areas and the landscape assumed the form we know today. The rivers deposited sediments into the down-folded basin east of Carquinez Strait and the Vallejo Hills creating lands of Suisun Marsh. Minor geological uplifts, from mid- to late-Pleistocene, completed the framing of the Marsh. During this period, an orogeny uplifted the Potrero Hills and further isolated Suisun Marsh from the Central Valley.

Climate

Winters in Suisun Marsh are mild and wet; summers are warm and dry. The rainy season generally begins in November and continues into March. Average rainfall is about 20 inches per year. The climate is tempered by cool, moist winds that blow from the Pacific Ocean and San Francisco Bay through Carquinez Strait, hence the Indian name "Suisun" or "west wind". The wind blows consistently through late spring, summer, and early fall.

Soils

Suisun Marsh soils are mixtures of hydrophytic plant remains and mineral sediments. As the Marsh formed, plant detritus slowly accumulated, compressing the saturated underlying base material. Mineral sediments were added to the organic material by tidal action and during floods. Generally, mineral deposition decreased with distance from the sloughs and channels (Miller *et al.* 1975). Suisun Marsh soils are termed "hydric", because they formed under natural tidal marsh conditions of almost constant saturation. Because they were formed under tidal salt marsh conditions, the soils are also considered saline.

Soils of the Marsh include soils of the Reyes, Tamba, Joice, Valdez, and Suisun series. All are saline and poorly drained, and each presents different challenges to the wetland manager. When allowed to dry, the hydric soils tend to subside, thus lowering the elevation of the pond bottoms. Reyes and Tamba soils become strongly acidic if exposed to air and allowed to dry. Suisun and Joice soils are difficult to leach effectively, because capillary action and hydrostatic pressure in these organic soils bring saline water upward though the soil profile, making it difficult to maintain low root zone salinity. In addition, Joice soils are prone to cracking.

Suisun Marsh encompasses 15-20 major sloughs and four embayments: Grizzly, Suisun, Honker, and Little Honker bays. Six major creeks flow into the Marsh: Green Valley, Suisun, Ledgewood, McCoy, Union, and Denverton. Many minor creeks also flow into the Marsh.

Land use

Suisun Marsh was once part of a vast tidal basin that has been modified by levee construction (beginning in 1850), industrial development, and agricultural conversion. A steady progression of diking, especially during the 1930s, has continued into the 1970's. Today the Marsh contains about 52,000 acres of managed wetlands and 6,300 acres of unmanaged tidal wetlands. Bays, sloughs, and upland grasslands make up the remainder of the habitat.

Most of the 52,000 acres of managed wetlands is privately owned and managed as waterfowl hunting clubs by 158 landowners. CDFG owns and manages more than 14,500 acres, including the Grizzly Island Wildlife Area, Hill Slough Wildlife Area, Joice Island Unit of the Grizzly Island complex, and the Peytonia Slough Ecological Reserve in the eastern region of the Marsh. CDFG also owns and manages the Grey Goose, Gold Hills, Cordelia, and Goodyear units in the western Marsh.

Recreation

Recreational resources in the Marsh consist of wetland and upland areas used for waterfowl, pheasant, and dove hunting. The sloughs are used primarily for warm water fishing, boating, and water sports. CDFG manages the Grizzly Island and Joice Island Wildlife Management Areas and several areas in the western Marsh that are used for waterfowl and upland game hunting and dog training. Other recreational activities include shore fishing, birding, picnicking, nature study, and sightseeing.

Popular public facilities include Hill Slough Wildlife Area, Grizzly Island Wildlife Area, and Rush Ranch. Hill Slough Wildlife Area is a CDFG-administered area 0.25 mile south of State Highway 12 on Grizzly Island Road. Rush Ranch is a 2,070-acre property on Grizzly Island Road administered by Solano Land Trust featuring an interpretive program, about 7 miles of trails, and scheduled public nature tours.

Public boat access to Marsh sloughs is available at Pierce Harbor on Goodyear Slough, Beldon's Landing boat ramp on Grizzly Island Road, and launching facilities at the Suisun City marina.

CDFG estimates up to 60,000 user days annually on its managed sites; 37,000 user days annually on private duck clubs; and 40,000 user days on the sloughs and bays.

Vegetation

The seasonal wetlands are managed specifically for the growth of waterfowl food plants — primarily alkali bulrush, fat hen, and brass buttons — as recommended in the Individual Ownership Adaptive Management Habitat Plans. Other common wetland plants include pickleweed, hard stem bulrush, California bulrush, narrow leaf cattail, saltgrass, alkali heath, and sea purslane.

Invasive species such as perennial pepperweed, Phragmites, and cocklebur, are prevalent throughout Suisun Marsh. Landowners have taken actions to discourage the growth of these problem species and the SRCD coordinates a pest weed control program that seeks cost-share funds to assist landowners.

Fish

Suisun Marsh bays and sloughs provide habitat for at least 45 species of fish, including the State and federally listed winter-run Chinook salmon, spring-run Chinook salmon, Central Valley steelhead, Central California Coast steelhead, delta smelt, and the popular nonnative striped bass. Fish species found in Suisun Marsh are listed in Appendix N.

USFWS, CDFG, and University of California at Davis have conducted several fish sampling programs in Suisun Marsh since 1979. Results are described in the annual Suisun Marsh Monitoring Program Data Summary Report (most recent is for water year 1994, published in July 1996) or the annual Fisheries Monitoring Report compiled by the DWR. Both reports are prepared as conditions of USACE Permit 16223E58, BCDC Permits 35-78(m) and 4-84(m), and the Suisun Marsh Monitoring Agreement and Preservation Agreement.

Winter-run Chinook salmon, fall-run Chinook salmon, spring-run Chinook salmon, Central Valley steelhead, delta smelt, and their habitats are listed under the Endangered Species Act.

Winter-run Chinook salmon have recently suffered severe declines in abundance. Construction of Shasta Dam and Red Bluff Diversion Dam, unsuitable water temperatures, and entrainment at poorly screened diversions has contributed to the decline. There is relatively little information on how conditions in the Suisun Bay area and Suisun Marsh affect winter-run Chinook salmon. In general, however, it is known that Suisun Marsh is a rearing and migratory corridor for juvenile Chinook and a migratory corridor for adult salmon. Tidal marshes and shallow water may provide important rearing areas for salmon. Benefits of these habitats include contribution of nutrients, availability of rich feeding habitat, potential refugia from predators, and habitat for the physiological adaptation of juveniles to seawater. Therefore, the availability of tidal marsh and shallow-water habitat could provide important rearing areas for juvenile winter-run Chinook and other races of Chinook salmon, probably most notably fall Chinook, which migrate to the estuary at smaller sizes.

Delta smelt has also suffered a dramatic decline in abundance. Delta smelt is found only in the Sacramento-San Joaquin River estuary, particularly in the Suisun Bay region. Its abundance depends on environmental conditions, most likely conditions affecting survival of eggs and young fish. This document analyzes anadromous fish and EFH; it does not analyze impacts to delta smelt because they are not an anadromous species.

Splittail, a proposed species, has disappeared from much of its native range because of dams, diversions, and agricultural development and is now largely confined to this estuary. Its abundance is strongly tied to freshwater outflow. This document does not analyze impacts to splittail because they are not an anadromous species; it addresses impacts to anadromous fish species and EFH.

There are four candidate fish species in Suisun Marsh: green sturgeon, longfin smelt, Pacific lamprey, and river lamprey. Green sturgeon is not abundant in any Pacific Coast estuary and little is known about its life history. The longfin smelt is abundant in many Pacific Coast estuaries but information regarding population sizes and fluctuations is limited. Little is known about the life history or abundance of the Pacific lamprey and river lamprey.

Chinook salmon and delta smelt were used for impact evaluation. Little specific information is available for the other species of special concern but conditions required for Chinook salmon and delta smelt will benefit the other fish species. The primary concerns are diversions and migratory delays.

All new diversions in Suisun Marsh are required to have fish screens with approach velocities appropriate for delta smelt and Chinook salmon. Approach velocities for delta smelt are 0.2 ft/sec., which is lower than those required for Chinook salmon and are, therefore, the velocities used in designing new fish screens in the Marsh. Fish screens will benefit all potentially affected fish species.

Additional information on EFH species is found later in this document under species-specific assessments.

Wildlife

Suisun Marsh and Suisun Bay provide winter habitat to a wide variety of wildlife, most notably waterfowl such as northern pintail, mallard, widgeon, green-winged teal, shoveler, ruddy duck, and canvasback. Upland game such as pheasants, wintering shorebirds, and mammals such as river otters abound in the Marsh. A herd of tule elk resides on Grizzly Island. Listed wildlife species include Salt Marsh Harvest Mouse (SMHM) and several species of birds such as California Clapper Rail and Black Rail.

Of the listed species of birds, the California brown pelican and the bald eagle are rare in Suisun Marsh, and do not use the Marsh every year. The American peregrine falcon is a winter resident, commonly observed foraging along Suisun Bay and Grizzly Bay shorelines. Aleutian Canada goose uses the Marsh only sporadically. California least tern is commonly observed foraging along Suisun channels, particularly Montezuma Slough. The highest abundance of California black rail in the estuary has been recorded in North Bay marshes, specifically in tidal marshes of Suisun Marsh and Napa Marsh. The birds are rarely seen, not only because their abundance is low, but also because they are secretive in nature.

Candidate wildlife species include two species of wood rat, six species of bat, and the Suisun ornate shrew. There are few recent records of Suisun ornate shrew and its status and distribution are poorly understood.

There are five candidate bird species. Ferruginous hawk is scarce and rarely seen in Suisun Marsh. Both Suisun song sparrow and the Suisun Marsh common yellowthroat were once abundant but are now restricted to disconnected fragments of habitat. Of the original number of Suisun song sparrows, only eight percent still exist. The western burrowing owl is uncommon in the Marsh.

The only candidate reptile species, western pond turtle, was once very abundant, but its numbers have declined due to habitat alteration and introduced predators.

Air quality

Southern Solano County is included in the Bay Area Air Quality Maintenance Area identified by the California Air Resources Board and U.S. Environmental Protection Agency because smog is often carried from the San Francisco Bay area into the Solano County region.

Good ventilation, favorable topography, and wind flow help prevent the buildup of oxidants and visual impurities during the spring and summer. The large flow of traffic on Interstate 80, Interstate 680, and State Highway 12 and aircraft from Travis Air Force Base are the chief source of pollutants in the area. In the fall, low temperature inversion elevations are likely to produce periods of high carbon monoxide and particulate concentrations. This is the result of a combination of decreasing wind speeds and agricultural burning.

Air quality is a regional problem. Vehicular emissions, industrial discharges, Travis Air Force Base, and agricultural burning over a wide area are sources of air pollution within Suisun Marsh. The California Air Resources Board and local air pollution control districts are responsible for enforcing air quality standards.

Transportation

Major highways along the perimeter of Suisun Marsh include Interstate 80 to the north, Interstate 680 to the west, and State Highway 12 along the eastern boundary. Solano County maintains several roads in the interior Marsh, including Grizzly Island Road, Chadbourne Road, and Rumsey Road. Many of the roads within the Marsh are privately owned and maintained. Southern Pacific railroad tracks run along the north and west sides of Suisun Marsh.

Public utilities

The Pacific Gas and Electric Company provides electrical service to the Suisun Marsh, primarily via above ground 12-kV transmission lines. However, many of the private ownerships, especially in the interior Marsh, are without electrical service.

Pacific Bell has telephone cable buried from the central office in Fairfield and terminating at the Teal Club. The Teal Club is at the confluence of Cordelia and Frank Horan sloughs. Buried telephone cable runs beneath Suisun Slough from the central office in Cordelia and terminating at the Joice Island Club near the confluence of Suisun, Cordelia, and Goodyear sloughs.

There is no potable water in Suisun Marsh. Water is brought in by truck to the CDFG Grizzly Island complex and individual ownerships transport water as needed for drinking and cooking. Many individual ownerships use wells to provide water for non-consumptive use.

Social and economic considerations

Most of Suisun Marsh is composed of seasonally managed wetlands, managed primarily by private hunting clubs. CDFG manages portions of the Marsh as wildlife refuge, and some of the upland areas in the northern part of the Marsh are in agricultural production.

The landowners manage most clubs directly, so employment is negligible, although some clubs employ caretakers who live on the premises and manage club operations. Local contractors are generally used for tasks such as dredging and levee maintenance activities.

Cultural and Historical Resources

On August 21, 1981, an Archeological Site Inventory record search was conducted for the primary management area by the Department of Anthropology, California State University in Sacramento, as part of the SRCD's RGP 9605-98D, issued by USACE. SRCD used this search and the cultural resources requirements outlined in expired permit 9605-98D for permit R20066E98, issued to SRCD on February 22, 1995.

There are no registered historic sites within the primary management. One previously recorded prehistoric resource has been identified, at the junction of Nurse and Cross sloughs.

Indian Trust Assets

Indian Trust Assets are legal interests in property held in trust by the United States for Indian tribes or individuals. Examples are reservations, rancherias, allotments, minerals, hunting and fishing rights, and water rights. Indian Trust Assets also include traditional-use areas. There are no identified Indian Trust Assets in the affected area.

PROJECT DESCRIPTION

Marsh management and the water control facilities that manipulate the timing, duration, and depth of flooding play a significant role in determining Suisun Marsh wetland plant communities. Wetland managers use various structures such as levees, ditches, water control structures, controllable topography, pumps, and fish screens to meet management objectives. A Guide to Waterfowl Habitat Management in the Suisun Marsh (Rollins, 1981) was developed as part of the Suisun Marsh Management Plan, which was mandated by Assembly Bill 1717 and prepared by SRCD. Due to increased regulatory restrictions over the past 20 years, SRCD developed 11 updated water management schedules (SRCD, 1998) to assist wetland property owners and managers. These schedules are guidelines because site-specific factors and endangered species closures vary in different regions of the Marsh in different water years. Factors that dictate the management schedule for each property are location in the Marsh, water control facilities, and water year type. For example, the northwest portion of the Suisun Marsh on Cordelia Slough is unaffected by endangered species closures. Montezuma Slough is affected by all closures. The northeast corner above Nurse Slough is under Chinook salmon restrictions but is not affected by Delta smelt restrictions. The Grizzly Bay and Honker Bay properties are under Delta smelt restrictions but not under Chinook salmon restrictions (Figures 1 thru 4).

Most wetland managers in the Suisun Marsh begin flooding their wetlands around October 1 in preparation for the fall migration of waterfowl. When possible, wetland managers of the Suisun 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. The wetlands are drained or circulated at low tide when the water elevation in the diked wetland 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 eight to twelve inches. After initial flood-up, water is diverted from adjacent sloughs, circulated, and then drained while maintaining water at eight to twelve inches deep. Compared to the initial flood-up period, relatively small amounts of water are exchanged between the sloughs and the ponds during circulation. Water circulation maintains water quality and prevents stagnant areas from developing. Circulation also helps prevent the increase of pond water salinity from evaporative loss and helps maintain natural soil salinities.

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

Levees (exterior/interior)

Exterior levees are embankments that prevent uncontrolled flooding of marshland due to tidal action. Exterior levees allow for management of water outside and inside the managed wetland. The crown of these levees is optimally about 9 feet above zero tide with a 12-foot top width. Exterior levees are used in conjunction with interior levees, ditches, and water control structures to control water on the land they surround.

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.

There is routine repair and maintenance required on exterior and interior levees. Typical levee maintenance work includes restoring levee contours, levee resurfacing, repair of gates and other water control structures, mowing vegetation, discing levee soils, and embankment repair. Levees may require maintenance due to storm events, wave action, levee subsidence, and rodent damage.

Ditches (primary ditches/secondary ditches/"V" ditches)

Primary ditches form a network of aqueducts that usually originate and terminate at exterior levees. The purpose of the primary ditch system is to allow a managed pond to be flooded and drained within a 30-day period. 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.

Secondary ditches, usually found 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. These ditches connect "V" ditches to primary ditches and ultimately empty out to water control structures.

"V" 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. "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 deposition on the soil surface. "V" ditches are at least 18 inches wide and 18 inches below the adjacent ground elevation.

The maintenance of ditches primarily involves removing obstructions caused by vegetation, debris, and siltation. Maintenance is performed so that ditches retain the capability to flood and drain the pond in 30 days or less.

Water Control Infrastructure

There are three primary types of exterior water control structures in the Suisun Marsh:

Flood Structure: This water control structure is used to divert water at high tide from an adjacent tidal slough into a managed wetland unit. These diversions can range from 12'' to 36" 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 at 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.

Drain Structure**:** This water control structure is used to drain water at low tide from managed wetland units into the adjacent tidal slough. These drainage structures typically range from 24’’ to 48” in diameter and are sized to maximize drainage opportunities at low tide. These structures are typically fitted with flap gates or screw flaps on the tidal side of the exterior levee. Drain structures are set in the exterior levee at the lowest elevation possible to maximize drainage potential, but high enough to avoid siltation during periods of non-operation. The interior side of the pipe is typically an open pipe to maximize drainage or a flashboard riser to maintain a minimum water level within the managed wetland unit. Drainage structures are typically located at the lowest pond bottom areas of a managed wetland unit or at the end of primary interior supply ditches. Discharge location on the tidal slough is a major consideration for the locations of drain structures. Siltation in discharge channels can render drainage structures inoperable. Therefore, it is desired to locate drainage structures in highly energetic channel locations close to deep water with significant tidal currents to keep drainage channel siltation to a minimum.

Dual Purpose Structure: This water control structure is used for both flooding and draining of managed wetlands at the same location. These dual-purpose structures are typically sized to maximize drainage opportunities at low tide and are only minimally opened when diverting water. These structures are typically fitted with screw flaps on the interior and exterior side of the exterior levee. While these structures are being utilized for drainage it is impossible for them to divert water into the managed wetlands. Dual-purpose structures are used as drains an estimated 70% of the time and 30% as flood structures. Flooding periods are typically the initial flood up in October and periodic leach cycles in the spring, depending on habitat and weather conditions. These structures are set in the exterior levee at the lowest elevation possible to maximize drainage potential but avoid siltation during periods of non-operation. Dual-purpose structures are typically located at the end of large primary interior supply ditches that convey water to and from the managed wetland areas most effectively. The discharge location on the tidal slough is a major consideration for the location of these structures. Siltation in discharge channels can make drainage impossible. Therefore, it is desired to locate drainage structures in highly energetic channel locations close to deep water and with significant tidal currents to keep drainage channel siltation to a minimum.

The purpose of water control structures (the combination of a pipe and component parts attached to the ends of a pipe, depending on the pipe’s intended purpose) 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. 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 (Rollins, 1981).

Water control structures, except weir boxes, are constructed from stainless steel, plastic, or galvanized steel. The six most commonly used water control structure component parts used for flooding and drainage of ponds are culverts, flap gates, slide/flap gates, screw gates, flashboard risers, and flashboard (weir) boxes.

Culverts are corrugated steel or high-density polyethylene pipes placed in a levee for the purpose of conveying water from one side of the levee to the other. Flap gates are hinged metal covers affixed to the end of a culvert. Flap gates are designed to allow the free flow of water in one direction and prevent back flow in the opposite direction. Water pressure against the flap controls the rate of flow through the gate.

Slide/flap gates are the most versatile and common gates used in the Suisun Marsh. 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. Slide/flap gates are nearly always installed on the outboard side of levees and in combination with flashboard risers located on the inboard side. In the lowered position, 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. Slide 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 slide/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.

Flashboard risers consist of a length of corrugated metal or plastic pipe cut in half longitudinally and placed vertically on top of the inboard end of an inlet or outlet culvert. The bisected culvert is fitted with grooved metal frames on each side. Wooden planks are inserted one on top of the other into the grooved frame, thus preventing water (except that which spills over the planks) 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.

All water control structures should be maintained in good working order, free of debris and silt. Leakage should be kept at the minimum practical and necessary repairs should be made promptly. Plastic water control structures have a possible life expectancy of 20-30 years where steel is expected to last 8 to 12 years on average.

Diversion of water from the Suisun Marsh tidal sloughs into the managed wetlands of the Marsh is much different than that of an agricultural diversion in the Central Valley of California. Due to the daily and seasonal variations of tide stage in the marsh, floodgates do not function 24 hours a day. At low tide (twice daily) the water elevation within the managed wetland units is higher than the tidal sloughs. Therefore, diversions may only operate for less than 12 hours a day and the volume and velocity vary greatly based upon the extent the gate is open and the head pressure created by the high tide stage. Managed wetland units serviced by these diversions are finite in volume. Once the desired managed wetland volume is achieved (typically 8 to 12 inches of water depth), diversions are throttled back to the minimum amount necessary to maintain stable water levels. These diversions are not like diversions delivering water for consumptive use or for agriculture in a riverine environment, which are capable of taking water 24 hours per day. During periods of heavy winter and spring rains, compounded with high tides from delta outflow, pond water elevations can rise to undesirable levels for extended periods of time within the managed wetlands. Improvements in water control facilities improve the capability of wetland managers to avoid excessively high water levels and prevent inundation of shallowly flooded emergent vegetation, pond margins, and upland refugia that provide SMHM habitat within the managed wetlands. Most diversions are completely closed several days in advance of winter storms and will not be reopened for circulation until water levels have receded to the desired level in the managed wetlands. In extreme high flow (flood) events, properties will close diversions for an even more extended period of time to avoid over-flooding a property because drainage facilities cannot compensate for excessive inflow from rain and levee overtopping. Similarly, leach cycles may be suspended in years with above-average spring rains to take advantage of the natural leaching effect of rainwater on the soils.

SCOPE OF WORK – MAINTENANCE ACTIVITIES

A. NO EFFECT

Of the twenty-one work activities authorized under RGP 3, twelve have no impact on EFH or ESA listed fish species (Table 1). These activities take place entirely on the managed wetland pond bottoms (inland side of the exterior levees), there is no in-water work, and there is no direct hydraulic connection between the sites where these activities occur and exterior (tidal) areas.

B. NOT LIKELY TO ADVERSELY AFFECT ESA LISTED FISH SPECIES AND MINIMAL ADVERSE EFFECT TO EFH

Seven of the twenty-one activities authorized under RGP 3 and the two newly proposed activities are not likely to adversely affect ESA listed fish species or EFH (Table 2). Descriptions of each work activity in this category and an explanation of why the activity is not likely to affect are below.

1) Repair exterior existing levees – dredging from the tidal sloughs of the Suisun Marsh for levee maintenance is not permitted under the current RGP. All levee maintenance must be carried out using materials taken from interior areas of the marsh or by using permitted import materials. Currently, the most common practices in the Suisun Marsh involve the removal of accumulated silt and vegetation from existing water circulation ditches within managed wetlands and placing borrow material on the crown of adjacent levees to raise the crown to original height and/or improving interior side slopes. Another option available to landowners is the grading of pond bottoms and high ground areas to provide levee maintenance material. It is unlikely that a significant amount of

levee repair material would be lost to the outboard side of an exterior levee below the mean high water line. Any material that might trickle down the outside slope of the levee from the crown would probably not affect vegetated areas and may only cause slight and very temporary turbidity.
2. Coring of exterior levees – the purpose of this activity is to stop the flow of water through rodent holes and cracks. To core a levee, a two-foot wide trench is excavated in the levee crown and the material is placed on the crown of the levee adjacent to the excavation site. The trench is then backfilled using the same material that was excavated. The material is compacted during the backfilling process to seal the levee. The levee crown is normally twelve feet wide and therefore there is little chance for excavated soil to be wasted onto the outside slope of the levee.

3. Repair of exterior water control structures – this repair involves the replacement of component parts of pipes through exterior levees (gates, stubs, or couplers) but not the replacement of the pipe itself. If a water control structure fails, the result is likely uncontrolled flooding of managed wetlands. This work is done at low tide to provide access to the pipe, to avoid entrainment of fish, and does not involve any excavation of sediments from the exterior slough. In-water work is done by hand (uncoupling the old structure and re-coupling the new structure) and generally a ground crew lifts the damaged structure out of the water and lowers the new structure into place. Some very temporary turbidity may result from the actions of the in-water work. There is generally no vegetation present because exterior pipes are set at a depth that precludes emergent vegetation growth.

4. Install, repair, or re-install water control bulkheads – a bulkheads strengthen newly excavated sections of levee and avoids additional turbidity after completion of the in-water work by containing loose soils that may otherwise fall into the exterior slough. Bulkheads are built to stabilize and strengthen the levee around water control structures and prevent the erosion of disturbed soils when exterior pipes are originally installed or replaced. This 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. Some very temporary turbidity may result from the actions of the in-water work.

5. Installation of drain pumps and platforms – installation of a drain pump and platform takes place entirely within the managed wetland (inland side of the levee), there is no in-water work, and there is no hydraulic connection between the sites where this activity occurs and exterior (tidal) areas. On rare occasions, the drainpipe will be set high in the profile of the exterior levee so that the pipe does not block vehicle traffic. It is unlikely that a significant amount of levee material would be wasted to the outboard side of an exterior levee below the mean high water line. Any material that might trickle down the outside slope of the levee from the crown would probably not affect vegetated areas and may only cause slight and very temporary turbidity. New drain pumps will not change the amount of drain water discharged into the exterior sloughs since diversions will not increase.

6 – 7. Pipe replacement for an existing exterior flood or dual-purpose gate or pipe replacement for an existing exterior drain gate – these two operations will have identical ESA and EFH impacts. An existing pipe is replaced at low tide. The new pipe is pre-assembled on the crown of the levee with the appropriate control structure components at each end of the pipe. A trench is excavated over the old pipe and the pipe is removed. Replacement pipes are typically placed in the same location as the existing structure, the trench is backfilled, and the backfilled material is compacted. Because of the depth at which the existing structure is set, there generally is no existing emergent vegetation in the area to be excavated. In the case of pipe replacement where emergent vegetation may have re-established, impacts to fisheries habitat would be a very temporary increase in turbidity and the loss of sparse emergent vegetation.

8. Brush boxes (proposed new activity) – the USFWS requires the SRCD to employ levee maintenance methods that do not utilize riprap, pursuant to the 1994 Biological Opinions from NMFS and the USFWS. A typical erosion site consists of a semi-circular scallop that protrudes into the existing berm. Under common levee maintenance practices, scallops would be treated with the placement of riprap, resulting in the potential loss of fisheries habitat. Brush boxes (biotechnical bank restoration) offer an alternative to the use of riprap. This method of levee stabilization uses natural materials and native plants for capturing sediment to stabilize and protect exterior levees while also providing fisheries habitat (Figure 5).

Brush boxes, brush bundles, and ballast buckets will be placed below the mean high water mark and anchored with tree stakes. Brush boxes and brush bundles are dead branches that are staked into the ground or wrapped in coconut fiber. Ballast buckets are organic, biodegradable buckets planted with native wetland species such as tule, three-corner bulrush, and Baltic rush. Brush boxes will not include any in-water work because all work will be done at low tide. This work is also done entirely by hand, reducing the sedimentation that can occur with mechanical work. After time has allowed for the build-up of sediment and the growth of native plants, the exterior levee will be stabilized, it will be protected from further erosion, and habitat will be provided for fish and the macro invertebrates that they feed on.

9. Fish screen maintenance dredging (proposed new activity) – thirteen fish-screened diversions were installed on private properties between 1996 and 1998, 2 fish-screened diversions on DFG property, and 1 fish-screened diversion operated by DWR (Figure 6). The available service acreage of those fish screens are as follows: thirteen privately owned fish-screened diversions are available to service 6,121 acres, two DFG fish-screened diversions are available to service 3,721 acres, and DWR's Roaring River fish screen diversion services 10,116 acres. Fish-screened diversions in the Suisun Marsh provide a total of 19,958 acres access to screened water. Most of these screens are installed on channels that have sufficient water velocities to avoid siltation. However, some of the fish screens experience significant siltation problems. Silt is deposited around these screens, which impedes the operation of the screen and screen cleaning brushes. Every fourth year a relatively small amount of material is proposed to be

removed from the fish screen basins (about 20 cubic yards each). Alternative measures (trying to move silt by hand) have been ineffective. Potential adverse effects include direct removal/burial of organisms and turbidity but the adverse effect of having nonfunctional fish-screened diversions far outweighs any temporary effects of maintenance dredging. Timing dredging for when sensitive fish species are present in lower densities (July 1st through October 1st) can reduce impacts. Dredging will be done at low tide to eliminate in water work and minimize turbidity, as the tide returns the fish screen will be opened to allow turbidity to be drawn into the managed wetland. Dredge spoils will be placed on the inboard slope of the exterior levee adjacent to the fish screen.

C. MAY AFFECT ESA LISTED SPECIES AND ADVERSE EFFECT TO EFH

Two of the twenty-one activities authorized under RGP 3 may affect ESA listed species and adverse effect to EFH (Table 3). Descriptions of each work activity in this category and an explanation of why the activity may affect are below. Measures to conserve and enhance fisheries habitat (Best Management Practices or BMP's), will minimize any possible adverse impacts of these activities and are discussed in greater detail later in this document.

1. Replace previously existing riprap on exterior levees – placement of riprap occurs on the tidal side of existing exterior levees in the minimum amount necessary for bank stabilization. Exterior levees with a vegetated berm, or which are not in an area with high wind and wave exposure, do not need riprap. The RGP 3 only permits riprap to be placed on exterior levee banks in those areas with previously existing riprap. When riprap is placed in areas with existing riprap, there is usually no emergent vegetation present and care is taken not to uproot or destroy any vegetation that may have re-established. Those areas that receive direct wave impacts have historically been fortified with riprap and require maintenance as needed. If riprap is lost during a storm event, riprap from the upper side slope of the levee slides down the face of the exterior slope of the levee, scouring off any emergent vegetation. In the case of riprap placement where previously existing riprap has been lost, and where emergent vegetation may have re-established, impacts to fisheries habitat would be a very temporary increase in turbidity and the loss of sparse emergent vegetation. The installation of brush boxes would provide a beneficial alternative to placement of riprap.

Under the current RGP, existing riprap may be replaced but no new riprap may be placed on the exterior of levees in the Suisun Marsh. There are 228 total miles of exterior levee in the Suisun Marsh (RAMLIT, 1983) but there is no information available as to the total number of miles that currently has riprap. According to SRCD records, an average of 945 cubic yards of replacement riprap was used in the years 2000, 2002, and 2004. These 945 cubic yards converts to approximately 1,890 lineal feet of riprap and the 1,890 lineal feet represents 0.16 % of the total 228 miles of exterior levee. This illustrates the relatively small amount of riprap that is replaced in an average year and even though it is theoretically possible to replace all the existing riprap in a given year, it is highly unlikely due to the high cost of replacing riprap. For economic reasons, riprap is usually only replaced as a last resort to preserve exterior levees.

2. Installation of new exterior drain structure - a new drain pipe is installed at low tide and new discharge locations would be selected where discharge channels already exist or exterior levees have no vegetation. A trench is excavated in the exterior levee as the tide recedes. The trench should be completed just before the water level reaches its lowest point and there is no in-water work. The new pipe is pre-assembled on the crown of the levee, usually with a flap gate on the outside and flashboard riser or screw gate on the inside. Before the tide starts to rise, the new pipe is placed in the trench, the trench is backfilled, and the backfilled material is compacted. Impacts to fisheries habitat would be a very temporary increase in turbidity and the loss of sparse emergent vegetation.

Effects of drainage operations

<u>Regions of the Marsh</u> (based upon entrainment potential and water quality considerations) (Figure 7)

Region 1 **–** The western and northwestern portions of the Suisun Marsh, primarily west of or adjacent to the Southern Pacific railroad. Managed wetland units diverting and draining into medium to small tidal sloughs characterize this area. Some of these tidal sloughs are significantly influenced by fresh water inflow from the Green Valley, Suisun, and Ledgewood Creeks. Additionally, there are several dead end sloughs in this region of the Marsh in which tidal exchange is minimal.

Region 2 **–** This is the central portion of the Marsh, fronting Suisun, Cutoff, and a small portion of Montezuma Slough. This region of the Marsh is characterized as managed wetland areas which flood off of small tidal slough, but primarily drain into Suisun Slough, the second largest tidal slough in the Marsh or Montezuma Slough. Suisun Slough is a large highly energetic channel similar to Montezuma Slough, terminating at Grizzly Bay and running north into the interior heart of the Marsh.

Region 3 **–** This is the central and southern portion of the Suisun Marsh and represents the largest geographic region of the Marsh. This area includes Grizzly Island including Van Sickle, Hammond, Simmons, Wheeler, Chipps, Upper and Lower Joice Islands. Montezuma Slough, the Sacramento and San Joaquin Rivers, and Grizzly, Suisun, and Honker Bays hydrologically dominate this area. All of these channels and bays are highly energetic with large daily movements of water driven by tides, delta outflow, wind, and the Montezuma Salinity Control Structure. This region of the marsh has had significant investment in fish screen facilities over the last 15 years with over 19,958 acres of managed wetlands served by fish screens. The presence of numerous fish screened facilities and the DWR Roaring River fish screened water conveyance facility has changed the management strategies of these managed wetlands. Most of these wetland areas obtain their water from Montezuma Slough and drain to the bays if physically possible. If not, then drainage of the wetland areas occurs directly into the large, tidal Montezuma slough.

Region 4 – Little Honker Bay, Nurse, and Loco Sloughs characterize the northeastern portion of the Suisun Marsh. Managed wetland units flood and drain primarily into medium to large tidal sloughs and Little Honker Bay in this area of the Marsh.

Table 4. Total Water Diversions (WD) in Suisun Marsh (SM)

	Flood	Drain	Dual	Pump	Fish Screens
Region 1	18	40	67	1	
Region 2	6	16	30	2	
Region 3	32	63	32	14	16
Region 4	4	8	21	0	
Total WD Types	60	127	150	17	16
Total WD for SM	370				

DWR has monitored the quality of drain water of selected ownerships in the Suisun Marsh since 1987. The focus of the monitoring was on specific conductance with limited data on water temperature, dissolved oxygen, and pH levels in March 1994 for western Suisun Marsh sloughs. The average salinity for Montezuma Slough at Beldon's Landing from April '00 to July '05 was 7 ppm (max 16 ppm, min 2 ppm) and the average temperature was 12 degrees Celsius (max 18 degrees C, min 6 degrees C). Specific conductance in drain water was generally similar or slightly higher to slough water. In Goodyear Slough, the pH and temperature of drain water were comparable to slough water and dissolved oxygen levels appeared sufficient in both drain and slough water (NMFS Biological Opinion, 1994).

Unpublished data from one Suisun Marsh wildlife survey conducted in 1999/2000 appears to show similar trends in salinity and temperature of flood and drain water throughout the Marsh. On average, salinity and temperature was similar to or slightly higher in drain water than flood water.

"Black water" is a localized occurrence (Region 1) in the Suisun Marsh caused by anaerobic bacterial decomposition of vegetation in wetlands during low dissolved oxygen (DO) events. Since "black water" has come to the District's attention, the District has worked with landowners in the affected areas (Region 1 wetlands adjacent to Boynton and Peytonia sloughs) to implement management modifications that have reduced the extent and severity of "black water" and improve dissolved oxygen conditions in discharge water. These management modifications include:

1. Elimination of discharge points into Boynton and Peytonia Sloughs. Discharge points have been relocated to a more energetic channel (Suisun Slough) with greater exchange rates to minimize impacts on the smaller channels.
2. Changes in cultural practices to discourage broad-leaved wetland vegetation growth. This reduces the amount of vegetative material in the pond to avoid creating low DO conditions immediately after flood-up.
3. Mow dense vegetation prior to flood-up. Mowed vegetation that has a chance to dry before flooding will create less oxygen demand during decomposition.

4. Circulate at maximum rates until water temperatures drop in late fall to improve aerobic conditions.
5. Flood and drain ponds rapidly prior to final flood to begin the decomposition process under aerobic conditions.

Anecdotal evidence suggests that these management modifications have been successful in reducing or eliminating "black water" occurrences. Although small changes in water quality may be seen, drain water probably does not significantly degrade water quality in the larger sloughs where winter-run Chinook more commonly occur and during the time period they are present. The range of dissolved oxygen levels, temperature, and pH are within safe levels for rearing and out migrating juvenile salmon.

Inefficient drainage facilities result in high evaporative losses and the accumulation of salts within the soils of the managed wetlands. For properties with low mean pond bottom elevations, even the lowest of tides are not sufficient to permit effective tidal drainage. Improvement of water management capabilities to meet the recommended 30-day flood/drain cycle increases the wetland manager's ability to control the hydroperiod within the managed wetlands. The length of soil submergence is a critical factor in wetland management, as it can determine composition of the resulting plant communities. By improving management capabilities and water control facilities, water levels can be controlled or reduced, thus improving wetland diversity, sustaining existing wetland plant communities, and preserving wildlife values.

The impact of new point-source drainage discharges on channel water salinity is expected to be minimal. Their operation would not increase the volume of water being discharged, but it would decrease the period of time the same volume of pond water is being returned to the bays and sloughs.   Suisun Marsh sloughs and bays are constantly circulating through the ebb and flood tidal cycles. The drainage water from managed wetlands is typically slightly more saline than that of the channels, which could result in a localized salinity increase at the discharge site. This impact would be minimal, because the resulting salinity would likely be within the existing salinity range. In addition, effects of decreased water quality are temporary. Dilution would occur quickly because of the large volume and exchange of water in Cordelia Slough, Suisun Slough, Grizzly Bay, Montezuma Slough, and Honker Bay.

Drain pumps and platforms primarily service 4 of the 158 parcels in the Marsh. Thirteen of those pumps are owned and operated by CDFG. All of the parcels with drain pumps use the pumps to dewater the remaining estimated 5% of their ponds that cannot effectively tidally drain. About 30% of landowners with pumps use their pumps for leach cycles. There is little additional opportunity for installing drain pumps due to their cost of installation and operation. It is estimated that drain pumps cost twice as much as draining by gravity in addition to operation and maintenance costs. With the escalating cost of electricity and fuels, landowners operate their pumps only at times of critical need for habitat management. Drain pumps don't substantially increase the volume of water discharged from a pond; they decrease the amount of time it takes to dewater. It is estimated that of the four ownerships that have pumps they only increase the dewatering capacity by 5%. Pumped drain water, because it is the last water drained from a pond in the summer, is assumed to have slightly increased temperature, salinity, and lower dissolved oxygen.

Placement of drain pumps minimizes the above compromises to water quality. Drain pumps are located adjacent to existing gravity fed drains and hydraulically active deep channel sloughs to avoid siltation. Discharging drain water into these large sloughs decreases the effects of lower quality drain water with large amounts of slough water through diffusion.

Effects of diversion operations

<u>Estimated annual average volume of water diverted for managed wetland operations</u>

The annual volume of water diverted into the Suisun Marsh managed wetlands unknown. There are many physical and operational aspects that complicate the calculation of an answer to this question. Some physical factors include the elevation of the diversion pipe, the length of time a water control structure is open, the daily tidal fluctuation of water (outside head pressure), volume of the pipe, how much the pipe gate is opened, velocity of water diverted into the managed wetlands, and water depth within the managed wetland (inside head pressure).

Without physical measurements of volumes of water being diverted into the managed wetlands, the development of an estimate was needed. The starting point for this evaluation is the determination of floodable acres within the diked managed wetlands. The most reliable source of information for this exercise is the CDFG Suisun Marsh Vegetation Mapping Survey completed in 2000. This GIS database was used to classify habitat types based on physical features and vegetation characteristics. The following information was compiled to determine floodable acreage within the managed wetlands:

Acreage of study area (below 10' elevation contour line)	65,127 ac.
Total upland types	13,924 ac.
Tidally influenced lands	7,586 ac.
Flooded managed wetlands	3,774 ac.
Non-vegetated features (Ditches comprise 1,576 ac.)	6,344 ac.
Floodable wetland vegetation	33,499 ac.
(Bays and slough were excluded from the summary)	
Flooded managed wetlands	3,774 ac.
Ditches	1,576 ac.
Floodable wetland vegetation	<u>33,499 ac.</u>
Total Floodable Acres	38,849 ac.
Permanently Flooded Ponds	<u>(-) 2,025 ac.</u>
Seasonally Flooded Managed Wetlands	36,824 ac.

Of the total floodable acreage, approximately 19,958 acres have fish screened water available for wetland management. Therefore, 36,824 acres minus 19,958 acres leaves approximately 16,866 acres of seasonally flooded managed wetlands without access to fish screened water.

The next question is what is the volume of water used to manage a typical wetland unit in one year? In the fall, the managed wetlands are flooded 8 to 12 inches deep on average for waterfowl hunting. The water depth provided in seasonally flooded wetlands allows the pond bottom to be reached by dabbling or tipping and is preferred by dabbling ducks for foraging (Batt et al., 1992). These wetland units are not like bathtubs with smooth, uniform bottoms and steep sides. Instead, these ponds tend to have significant topographical variation with vegetated areas and shallowly flooded margins to attract waterfowl. There are regions of ponds which may be deeper than 12 inches and primary and secondary ditches can be as much as 4 feet deep at discharge locations. Overall, it is assumed that the average volume of water used for initial flood-up and circulation of the wetland units during waterfowl season (mid-October to late January) is 0.75 acre foot per acre of flooded managed wetland. Fall flooding begins in late September and will continue until the wetlands are fully flooded in mid October. Initial flood-up is the most significant volume of water diverted the entire year for wetland management. This means that approximately 16,866 acres x 0.75 acre-feet of water are diverted over a 21-day period throughout the Marsh. When broken down on a daily basis this is roughly 602 acre feet or 74,000 cubic meters per day.

To assess the significance of this volume of water being diverted on a marsh wide basis DWR provided a summary of the volume of water of major slough channels in the interior marsh. These channels included Montezuma, Suisun, Nurse, Cordelia, Goodyear, Cutoff, Peytonia, and Shelldrake Sloughs. The volume of these sloughs was calculated as approximately 46,000 acre-feet at mean high water (when these gravity flow diversions would be operating) and 34,000 acre-feet at mean low water (from the RMA hydrodynamic model). This volume is equal to approximately 1.3% of the total slough volume diverted into the managed wetlands.

SRCD believes that this assessment would be accurate if the Suisun Marsh were a reservoir system. There is an additional physical factor that this evaluation does not consider related to looking at volumes in the context of daily tidal excursion and residence time of water in the sloughs. For example, the flow near Pittsburg, CA during a typical summer tidal cycle can vary from 330,000 cfs upstream to 340,000 cfs downstream.

Spring flood up begins in February and runs through April. Spring management requires drainage of the managed wetland and re-flooding to ½ of the fall management level (average 1 leach cycle per year). Drainage capabilities, spring weather and Delta outflow dictates when most properties can complete draining and re-flooding of the ponds. This means that approximately 16,866 x .375 acre-feet of water is diverted into managed wetlands in the spring for leaching and moist soil management of wetland vegetation. Broken down on a seasonal basis, water diversion volume is estimated at 6,324 acre-feet per year (over a 5 month period from February to June). The total average volume of water diverted per year of Suisun Marsh managed wetland operation (fish screened diversions excluded) is approximately 19,000 acre-feet (12,649 plus 6,324).

We feel that these figures over estimate the total volume of water diverted into managed wetlands because there are many areas of wetland vegetation within the managed wetlands that are unable to flood but exhibit flooded wetland characteristics (unflooded but saturated soils also support wetland vegetation) in the aerial vegetation survey. Additionally, three properties in the Marsh (totaling over 600 acres) receive treated sewer effluent for a portion of their flooding source. In the absence of actual measured diversion volumes, this approach was the best available information supported by large assumptions and cautious conclusions.

Water diversions in the Suisun Marsh are operated on a seasonal basis, with peak use in the late summer and early fall (mid-August through October). Managed wetlands divert water at this time in anticipation of waterfowl season (mid-October to late January). During waterfowl season, after managed wetlands have reached their initial desired depth (8 to 12" above mean pond bottom), water is minimally diverted from exterior sources for circulation. Diversions are utilized at only a fraction of their capacity so as to maintain pond water level (i.e. offset evaporative loss) and circulate water within the managed wetland.

After waterfowl season, managed wetlands are allowed to drain (intakes are closed) and one or two leach cycles are conducted, if possible. Leaching a pond consists of rapidly flooding and subsequently draining water to about 12" below mean pond bottom in order to remove surface salts from the wetland soils. Leach cycles lower soil salinity in an effort to promote more diversified wetland habitat.

Areas not affected by diversion restrictions conduct one to three leach cycles after the close of the waterfowl season; those affected by diversion restrictions usually are able to conduct only one. Each leach cycle takes about 30 days to complete.

Once leach cycles are completed, ponds are flooded to one half of the normal depth. This diverts much less water than at initial flood up. After the desired springtime depth is achieved, water is only diverted to maintain pond level and provide circulation. Ponds are re-flooded after leach cycles in order to support greater diversity in plant communities and to promote seed germination in shallow water. Shallow ponds also provide habitat for a diversity of local nesting and migratory water birds.

Water is then drained in early July to dry out the managed wetlands in preparation for summer maintenance activities. From July to September, the only water being diverted from exterior sources is for permanent ponds. There are five managed wetland units that are managed as permanent ponds in Regions 1 (1,235 acres) and 2 (790 acres) for a total of 2,025 acres in Suisun Marsh.

The Suisun Marsh supports a diverse assemblage of aquatic species, many of which spend only part of the year or part of their life cycle in the Marsh. Others move within the Marsh in response to their environmental requirements. Some fish - especially larvae and juveniles - could be diverted onto the interior ponded areas of the managed wetlands. Screened diversions will yield a net benefit to resident and migratory fishes, which are not protected from entrainment with unscreened diversions.

The principal impact associated with SRCD activities is expected to result from the diversion of water from natural sloughs through culverts and pumps into diked marshlands. Operation of water intake structures on exterior levees by private landowners is likely to entrain listed species when water is withdrawn from tidal sloughs. Juvenile salmon entrained through an intake onto managed diked wetlands will likely be lost to predation, temperature, physical injury, or physiological stress. Properties with deep, permanent, and remnant slough channels are assumed to act like refugia to entrained fish because they facilitate avoiding predation, thermoregulation (lower temperatures), and physiological stresses (higher dissolved oxygen and lower salinity). These factors may increase survivorship and increase an entrained fish's chance of escaping into tidal waters.

Entrainment Estimates from 1994 NMFS Biological Opinion

An estimate of entrainment loss was calculated for a dry water year type (1991/1992) and a wet water year type (1992/1993). Although more than 2 years of data are needed to represent the variability of biological and hydrological conditions, sufficient information pertaining to other years was unavailable. The following parameters were evaluated: (1) the distribution pattern of juvenile winter-run Chinook entering the Delta over time, (2) the proportion of juvenile Chinook migrating into Montezuma Slough, and (3) the proportion of water diverted from Montezuma Slough during the winter-run Chinook out migration. For entrainment estimates, the 1992/1993 USFWS sampling results are used to assess the timing and proportion of the juvenile winter-run occurrence in the Delta.

One method to estimate the proportion of juvenile Chinook salmon entering Montezuma Slough is to assume that juvenile salmon move in direct proportion to the flow split between Montezuma Slough and the Sacramento River. This assumption has been used and verified in other studies in the Northern Delta (Erkkila et al. 1950, Schafter 1980).

The total annual entrainment of juvenile winter-run Chinook in Montezuma and Tree Sloughs may range from 0.07 to 0.26% of year class production in wet and dry water years, respectively. An estimated 0.26% of juvenile winter-run production equals 702 fish out of 270,000 fish estimated for the 1992 year class production. Losses occur from December through April depending on the timing of winter-run Chinook out migration. It has been surmised that in tidal environments such as Suisun Marsh, entrainment rates of juvenile Chinook could exceed water diversion rates due to their feeding behavior on rising tides. The above estimate is for Montezuma and Tree Sloughs only and does not include losses in other Suisun Marsh sloughs. Based on the analysis in the 1994

Biological Opinion, the maintenance activities by the District to their water intake structures and levees, as well as the associated water management practices, are not likely to jeopardize the continued existence of winter-run Chinook salmon or result in the destruction or adverse modification of its critical habitat.

The 1994 NMFS biological opinion addressed entrainment estimates on the Sacramento River winter-run Chinook salmon. The District assumes that the proposed periodic maintenance activities will similarly affect other salmonid species such as Central Valley spring-run Chinook salmon *(Oncorhynchus tshawytscha)*, Central California Coast steelhead *(Oncorhynchus mykiss)*, and Central Valley steelhead *(Oncorhynchus mykiss)*, and their habitat.

Scope of Work and Best Management Practices (BMP's)

1. Repair of exterior existing levees consists of repairing the crown and restoring the 2:1 slope of the landward side of exterior levees with excavated material from the interior marsh. All material shall remain on the crown or landward side of the levee. Exterior levee repair is not done in the rain, eliminating run-off into the exterior body of water and therefore negative effects turbidity has on essential fish habitat. Dredging from tidal sloughs for levee maintenance is not permitted under the current Regional General Permit. All levee maintenance must be carried out using materials taken from the interior areas of the marsh or by using suitable import materials. Landowners importing any material except authorized rock material must obtain concurrence from the Regional Water Quality Control Board (RWQCB) that imported material from outside of the Suisun Marsh is acceptable before its use. Authorized work may not be conducted in the areas shown on the California Clapper Rail Breeding Habitat Maps between February 1st and August 31st.

2. Riprap is used (in the minimum amount necessary) to stabilize existing areas of riprap on exterior levees, dikes, and banks. Riprap is placed on the tidal side of existing exterior levees during low tide (minimizing in water work) where rock has washed away or subsided. Riprap shall not be placed on emergent vegetation (tules) nor shall emergent vegetation be uprooted or displaced during the placement of riprap.

3. Coring of levees is for repair of rodent holes to prevent levee failure. Material excavated from the trench of a cored levee is temporarily placed on the levee crown then used to backfill the trench. All material will remain on the crown of the levee. Levee coring is not done in the rain, eliminating run-off into the exterior body of water and therefore negative effects turbidity has on essential fish habitat.

4. Replacement and repair of exterior water control structures include flap gates, lift flap gates, slide/flap gates, flashboard boxes, weir boxes, and flashboard risers. Maintenance of a water control structure could include repair and/or replacement of a gate, bulkhead, flashboard riser, stub or coupler (neither excavation of a levee nor in water work is needed for water control structure maintenance). Water control structure maintenance will not change existing use or diversion capacity for the structures. No water control

structure repairs will change the existing use or diversion capacity of the structures. No new diversions can be installed or existing diversions enlarged without the installation of a fish screen.

5. Pipe replacement for existing exterior flood or dual-purpose gate consists of trenching across a levee, removal of an existing water control structure, placement of the new water control structure, and backfilling of the levee. Pipe replacement must occur in one low tide cycle to avoid water flow through the excavated exterior levee to eliminate the entrainment of sensitive fish species. The optimum time of year to replace exterior pipes is in the spring because of increased work time and to prevent the entrainment of sensitive fish species. Spring tides result in dramatically increased tidal ranges (lowest low tides) due to the earth's elliptical orbit and lunar cycle. All work is completed as the tide is falling or completely out, eliminating in-water work. Water control structures are fully assembled on the crown of the levee and then a trench is excavated over the old pipe. The old pipe is removed, the new one installed, and the trench is backfilled. If a bulkhead is present, the bulkhead is cut over the pipe and removed, then replaced upon installation of the pipe. The bulkhead is in place prior to backfilling the trench to prevent any loose soil away from entering the waterway. If no bulkhead is present at the gate location, riprap is typically in place to protect the levee toe from erosion. Pre-existing riprap is replaced to the minimum amount necessary to protect the levee toe. No new riprap will be added unless replacing previously existing riprap. This process usually takes less than 6 hours and no more than 8 hours. Pipe replacement is done at low tide so no water will flow into the property, eliminating the possibility of "taking" listed fish species. Exterior pipe replacement is not done in the rain, eliminating run-off into the exterior body of water and therefore negative effects turbidity has on essential fish habitat. One BMP that the District has implemented encourages landowners to replace failed metal pipes (lifespan of approximately 20 years) with high-density polyethylene pipes (lifespan of 50+ years). This BMP significantly reduces future need for pipe maintenance, repair, and replacement as well as the associated disturbance to fish species and their habitat. Pipe replacements will not change the diversion capacity of the water control structure.

Based upon a 1997 SRCD Suisun Marsh landowner survey, it was determined that approximately 26% of the exterior water control structures in the marsh had been replaced with either plastic or fiberglass pipes. This survey represented only 54 respondents, but was a good representation of privately owned lands within the Marsh. Since 2002, SRCD has determined that an additional 48 corrugated metal pipe (CMP) exterior water control structures have replaced with high-density polyethylene (HDPE) pipes. Based upon the Suisun Marsh Regional Diversion Evaluation (Table 4, Figure 7), SRCD has determined that approximately 370 exterior water control structures exist, servicing the managed wetlands in Suisun Marsh. If 26% of these water control structures were replaced by the fall of 1997 with HDPE pipes the total number would be 96 structures. In 2005, 20 existing CMP exterior water control structures have been approved for replacement. As a result, it is estimated that 164 (96 + 48 + 20) exterior water control structures will have been replaced with non-corrosive materials by the end of the 2005 construction season. This means that over 44% of the exterior water control structures will be HDPE by the end of the 2005 work season. Exterior water control structure corrosion resistance will nearly eliminate pipe replacement maintenance needs and minimize future environmental effects from exterior water control replacements.

6. Pipe replacements for existing exterior drain gates are similar to pipe replacements for existing exterior flood or dual-purpose gates. Pipe replacement occurs during a single low tide and gates are attached to the pipe prior to placement in the levee. The optimum time of year to replace exterior pipes is in the spring because spring tides result in dramatically increased tidal ranges (lowest low tides) due to the earth's elliptical orbit and lunar cycle. All work is completed as the tide is falling or completely out, eliminating in-water work. If a bulkhead is present, the bulkhead is cut over the pipe and removed, then replaced upon installation of the pipe. The bulkhead is in place prior to backfilling the trench to prevent any loose soil from entering the waterway. If no bulkhead is present at the gate location, riprap is typically in place to protect the levee toe from erosion. Pre-existing riprap is replaced to the minimum amount necessary to protect the levee toe. No new riprap will be added unless replacing previously existing riprap. Pipe replacement is done at low tide to eliminate the flow of water into the property eliminating the possibility of "taking" endangered fish species. Exterior pipe replacement is not done in the rain, eliminating run-off into the external body of water and therefore negative effects turbidity has on essential fish habitat. No pipe replacements will change the existing diversion capacity of the water control structure.

7. Bulkheads strengthen the levee around water control structures and increase the effectiveness of water control structures. Bulkheads direct water into the pipes which lay flush with the bulkhead reducing eddies and therefore erosion around the pipe. The reduction of levee erosion prolongs the life of the levee and minimizes repairs that decrease the chance of disturbing essential fish habitat. The bulkhead is in place prior to backfilling the trench to prevent any loose soil from entering the waterway. There is no in-water work when installing, repairing, or re-installing a bulkhead.

8. Pumps enable landowners to discharge water that cannot effectively tidally drain. Pumps are placed where existing drainage gates discharge water to minimize effects to essential fish habitat by localizing disturbance. Pump operation does not increase the volume of water being discharged; it decreases the period of time the same volume of pond water is being returned to the bays and sloughs. Pump platforms are the minimum size necessary to hold the pump and are constructed on the landward side of the exterior levee resulting in no disturbance to EFH.

The USACE concluded that these similar proposed water control structure replacement activities were not likely to adversely affect: (1) endangered Sacramento River winter-run Chinook salmon *(Oncorhynchus tshawytscha)*, threatened Central Valley steelhead *(O. mykiss)* or their critical habitat; or (2) no more than minimal and temporary adverse effects to essential fish habitat for Pacific salmon, groundfish, or coastal pelagic species. No in-water work will occur during these activities, and the introduction of sediment to the waterway should be sufficiently avoided and minimized provided the project is implemented and described. The NMFS concurred with a similar determination in its letter dated April 30, 2002 for previously authorized pipe replacements.

9. As a result of federal biological opinions, currently there are closures and restrictions in place regulating the unscreened intake of water onto managed wetlands in areas of critical habitat. Closures and restrictions extend from November 1st through March 31st, with no restrictions from the end of duck season (late-January) to February 21st. Landowners diverting water from the crosshatched sloughs (Figure 4) use no more than 25% of the water control structure's diversion capacity from November 1st to the last day of duck hunting season (late January). These landowners are prohibited from diverting water from the sloughs shown of the salmon closure map from February 21st to March 31st. Restrictions Summary: (Taken from RGP 3 File Number: 24215N for the SRCD, page 5 condition #12 and #14). Condition #12: "Landowners are prohibited from diverting water from the sloughs shown on sheet 15 (Figure 4) from February 21st through March 31st. The purpose of these diversion restrictions is to protect migrating salmon." Condition # 14: "While the diversion restrictions are in place the SRCD and DFG shall monitor gate closures. If an open gate is observed they shall immediately contact the owner and the gate shall be closed." Diversion restrictions result in an umbrella effect protecting other fish species. Critical habitat for Chinook salmon is listed as Montezuma Slough, lower Nurse Slough (from the confluence of Denverton Slough to Montezuma Slough), Denverton Slough, Cutoff Slough (including Spring Branch, First and Second Mallard Branch Sloughs), Suisun Slough (from downstream of confluence with Boyington Slough to Grizzly Bay), and Chipps Island.

EVALUATED SPECIES

Brown Rockfish (*Sebastes auriculatus)*

Distribution: Pelagic, in coastal waters, from Mipolito Bay, Baja California, to southeastern Alaska; also found in San Francisco Bay.
Salinity: Seawater
Season: Larval fish are born in winter and early spring and are pelagic in coastal waters. Early life stages of juveniles are pelagic and gradually settle to bottom in association with rocks, jetties, pilings, and aquatic vegetation. Adults are rare in the Suisun Marsh with one recorded capture by the CDFG Bay Study Sampling program in San Pablo Bay.
Spatial: CDFG San Francisco Bay Monitoring Program sampling data has collected on brown rockfish in 1984 in the sampling sites located in the Carquinez Straights. No other sampling programs have collected brown rockfish in the Suisun Marsh.

English Sole (*Parophrys vetulus)*

Distribution: Mostly in shallow coastal waters of southern estuaries although some are carried into bays and estuaries by currents. Found in the Pacific Ocean outside of San

Francisco Bay up the estuary to Suisun Bay. Bays and estuaries are considered important nursery grounds for English sole; particularly during the first year of life
Salinity: 10-40 ppt larval and juvenile life stages; adults seawater
Season: Larvae (<15-20 mm TL) are found in Suisun Bay from February through May. Sole larger than 20 mm TL will begin transformation to demersal habitat
Spatial: The English sole is not collected in various sampling efforts conducted in and around the Suisun Marsh. Wang (1986) reported that studies in the early 1980s have caught English sole larvae in Suisun Bay; however it was believed that tidal currents swept these species there. CDFG sampling efforts have been ongoing since the early 1980s and since 2000 20 mm trawl sampling effort has been conducted. Neither of these sampling efforts has collected an English sole.

Starry flounder (*Platichthys stellatus)*

Distribution: Mostly in coastal waters but also common in the Sacramento-San Joaquin estuary as far upstream as the lower portion of the San Joaquin River.
Salinity: Adults - seawater; larval and juveniles in fresh to brackish waters
Season: Spawning may occur in the San Francisco Estuary; however no gravid females have been collected. Larval fish are observed from about early winter to early spring with a majority of larval immigration occurring from late winter to spring. Larvae are pelagic for approximately two months and then settle to the bottom. Juveniles up to two years old will remain in the fresh to brackish waters of the estuary until age 2+ or three when they mature into adults and move to marine environments.
Spatial: Adult starry flounder are not present in the project area. However the larval and juvenile phases of Starry flounder are very abundant in the Suisun Marsh, Montezuma, Denverton, and Cordelia sloughs.

Green sturgeon (*Acipenser medirostri)*

Note: Not much data is available on green sturgeons however; it is assumed that their early life stages (larval and juvenile) are similar to that of the white sturgeon.
Distribution: Sacramento and San Joaquin Rivers, Suisun Bay, San Pablo Bay, and San Francisco Bay
Salinity: Freshwater (larval and juvenile life stages) to seawater (adults)
Season: Spawning occurs in the upper inland streams of the Sacramento River from February through June. Larval fish hatch in 4 to 12 days depending on water temperature. Larval fish swim immediately and a swept along with the flow for the first couple of days and then begin to develop their swimming ability. It is believed that they reside in the brackish water of the estuary in spring and summer periods and move upstream in late summer and fall.
Spatial: While most sampling efforts do not catch sturgeon (either green or white), we believe that adults may be present in the system from January through end of August. Larval and juvenile life stages are thought to inhabit the estuary until they are about four to six years of age. For the purposes of this effort we assume that sturgeon are present in the project area and may be affected by the implementation of this project.

Northern anchovy (*Engraulis mordax)*

Distribution: Open waters of San Francisco Bay and San Pablo Bay
Salinity: Seawater to mesohaline, found in Suisun Bay and Montezuma Slough
Season: Within the estuary spawning occurs from February through April. Adult anchovies are caught throughout the year by CDFG sampling efforts in San Pablo Bay.
Spatial: The northern anchovy is the most abundant species in the estuary (Baxter et al. 1999). For the purposes of this effort we assume that northern anchovy are present and may be affected by the implementation of this project.

Steelhead (*Onchorhynchus mykiss)*
Note: The analysis for impacts and life history for Central California Coast and Central Valley steelhead were combined and evaluated.
Distribution: Large tributaries of Sacramento-San Joaquin river system; some coastal creeks; and smaller tributaries within the estuary.
Salinity: Freshwater - spawning and rearing of juveniles; adults reside in marine environments until spawning
Season: December through April
--Green Valley Creek - adults have been sited by CDFG; Hanson Environmental, Inc.(Hanson 2002); and EPA (Leidy 2003).
--Suisun Creek – adults have been sited by CDFG (Leidy 2003), Hanson (2002), and Laurel (2004) and adults have been sited by Hanson (2002).
Spatial: Adult steelhead have been caught by anglers in the main stem of Montezuma Slough, however sampling efforts have recorded little if any catch of juvenile and yearling steelhead. During diversion monitoring program no juvenile and yearling steelhead were collected. U.C. Davis Suisun Marsh sampling has caught yearling steelhead in the fall and early winter on seven different occasions; however actual numbers caught are not available. For the purposes of this analysis we will assume that juvenile and yearling steelhead may be affected by the implementation of this project.

Chinook Salmon: (*Oncorhynchus tshawytsch)* - spring-run, winter-run, and fall-run

Distribution: Upper reaches of the Sacramento River and some tributaries; San Joaquin River (http://swr.nmfs.noaa.gov/hcd/cvschshd.htm)
Salinity: Freshwater - spawning and rearing of juveniles; adults reside in marine environments until spawning
Season: Adult upstream migration through Suisun Marsh -
winter-run salmon occurs from December through March
spring-run salmon occurs from late-March through June
fall-run salmon occurs from July through September
Spawning - winter-run salmon occurs from April through early August
spring-run salmon occurs from August through October
fall-run salmon occurs from October through December
Juvenile out migration through Suisun Marsh -
winter-run salmon occurs from December through April

spring-run salmon occurs from February through April
fall-run salmon occurs from April though June

Green Valley Creek – adults have been sited by CDFG

Suisun Creek – adults have been sited by CDFG

Spatial: Adult salmon have been recorded in the Montezuma Slough. Tagging programs have been conducted to evaluate the potential for migration impedance based on the operation of the Salinity Control Structure located in the upstream portion of Montezuma Slough.

Movement studies have estimated that anywhere from 0.81 to 2.74 percent of the juvenile fall-run sized salmon, calculated at Chipps Island, enter the Suisun Marsh via Montezuma Slough. Currently there is no way to calculate a population estimate or abundance for juvenile salmon populations. Sampling efforts on these life stages produces only and "index". Abundance estimates cannot be calculated based on these estimates. With this in mind and for the purposes of this effects analysis we assume that these species will be present in the system and are evenly dispersed throughout the Suisun Marsh.

DISCUSSION OF EFFECTS

The Interagency Ecological Program (IEP) web page was used to obtain fisheries information and can be accessed at http://iep.water.ca.gov. The IEP for the San Francisco Bay / Sacramento-San Joaquin Estuary consists of ten member agencies, three State (DWR, CDFG, and State Water Resources Control Board), six Federal (USFWS, Bureau, Geological Survey, USACE, NMFS, and Environmental Protection Agency), and one non-government organization (The San Francisco Estuarine Institute). These ten program partners work together to develop a better understanding of the estuary's ecology and the effects of the State Water Project (SWP) and Federal Central Valley Project (CVP) operations on the physical, chemical, and biological conditions of the San Francisco Bay-Delta estuary.

Another source for location and occurrence of fish species in one database searched was the Bay-Delta and Tributaries (BDAT). BDAT contains environmental data concerning the San Francisco Bay-Delta estuary with over fifty organizations contributing data to this project. The database includes biological and meteorological data and can be found at http://bdat.ca.gov.

A third source of data information is CDFG's 20mm trawl surveys which monitor post larval-juvenile fish distribution. Survey frequencies range from 8-10 annually and run on two-week intervals covering stations throughout the delta and downstream to the eastern portion of San Pablo bay and Napa River. Samples are collected using an egg and larval, rigid opening net constructed of 1,600-µm mesh.

Also used in this effects analysis is the CDFG diversion study. Approximately 13 diversions were monitored 24 hours per during the spring and fall flood up period from1996 to 1998 to determine if fish entrainment was occurring.

For each of the four regions of the Suisun Marsh, as described on page 18, one or more sampling stations were queried by species. BDAT staff has generated a map showing the monitoring stations (Appendix F). BDAT staff has acknowledged the difficulty in reading this map and due to the length of some sampling names and the great number of stations, the written description is more accurate than the mapped notation. For Region 1 the stations used were GY1 and GY3, both in Goodyear Slough. For Region 2 the two stations used were SU2 (Suisun Slough) and WL1 (upper Wells Slough). Data for Region 3 used the following three stations: 608MWT (Montezuma Slough at the east end of Roaring River), 610TNS (Montezuma Slough at road from Birds Landing), and 609TNS (Montezuma Slough at Nurse Slough). The station used in Region 4 was DV4 in Denverton Slough. Queries to this database could not be made in a way to isolate specific time periods, therefore, making any kind of temporal statements of occurrence by any one species impossible.

The distribution of each species and impacts is listed below:

Brown rockfish

There will be no effect to this species of the proposed RGP extension. The life stages of this species do not have a freshwater component. Neither has any presence data for brown rockfish been recorded in the IEP or BDAT databases or from the CDFG 20 mm trawl surveys.

English sole

There will be no effect to this species of the proposed RGP extension that allows maintenance activities within the Primary Management Zone of the Suisun Marsh. Their life stages do not have a freshwater component. No presence data for English sole has been found in the IEP or BDAT databases or from the CDFG 20 mm trawl surveys.

Starry flounder

In the late 1990s CDFG's diversion monitoring studies collected over 143 juvenile starry flounders. In addition to this sampling effort larval fish sampling in the main stem of Montezuma Slough and Suisun Bay collected in March of 2004, 76.58* (*expanded catch) starry flounder per 10,000 cubic meters of water sampled (see table below). The peak of juvenile presence in the Suisun Marsh is early spring. CDFG Bay Study sampling efforts have caught juvenile starry flounder with catch increasing in 2003 and 2004 over previous sampling efforts since 2000.

	Year					
Month	2000	2001	2002	2003	2004	2005
March	5	4	18	24	76	4
April	5	8	15	20	33	0
May	16	4	0	4	4	3
June	10	0	3	61	4	11

July	0	0	0	7	0	

Morrow Island Distribution System (MIDS) sampling by DWR is similar in study design to the late 1990s CDFG sampling effort of diversions in the Suisun Marsh and has resulted in the catch of no starry flounder during the sampling period: September 23, 2004 to May 26, 2005.

In Region 1 ninety-four starry flounders were caught in all months between the years of 1988 and 2000 as found in the DBAT database for the two Goodyear Slough sampling locations; length size ranged from 21 to 268 mm. In Region 2 forty-four starry flounders were caught between February and December; length size ranged from 20 to 126 mm. In Region 3 one was caught in May that measured 85 mm. In Region 4 thirty-two were caught in June and July; length ranged from 22 to 85 mm. This data can be found in Appendix A. The data reported in the DBAT database cannot be extrapolated to population numbers; however, the data shows trends in species catch both temporally and spatially.

Effects: All in-channel activities will occur at low tide where this species will not be present and the EFH impacts associated with these activities will be minimal. These activities are the first 12 listed in Table 1. After any of these activities fish usage will continue and will not be disturbed.

There may be a temporary EFH adverse impact caused by the installation of brush boxes on levees. Although there will be no in-water work and work will be done entirely by hand there remains the possibility of increased turbidity for a short time.

The EFH effect of dredging at fish screens will be minimal and temporary to the habitat. This work will be done at low tide to minimize turbidity and the fish screen will be opened on the incoming tide to draw any turbidity into the managed wetland on the incoming tide. There is the potential for an adverse effect caused by the removal of the substrate utilized for feeding or the removal of individuals.

There are likely to be no EFH effects on this species by diversion drainage operations in Regions 2-4. This area has much larger sloughs such as Suisun and Montezuma Sloughs with much larger daily movements of water. Additionally some diversions drain directly in the bays where possible. This species is somewhat more likely to be affected by water quality impacts from drainage in Region 1. DWR has monitored the quality of drain water for specific conductance taking limited data on water temperature, dissolved oxygen, and pH levels for these western sloughs and have found pH and temperature of drain water were comparable to slough water and dissolved oxygen levels and appeared sufficient in both drain and slough water. There exists the possibility for seasonal and temporary impacts of “black water” in this region caused from bacterial decomposition of vegetation under low dissolved oxygen levels. Landowners in this zone have made management modifications to reduce the extent and severity of low DO events and these management practices are detailed on page 19.

The estimated volume of water being diverted on a daily basis during the fall flood-up period is calculated to be approximately 16,866 x 0.75 acre-feet over a 21-day period throughout the Marsh. When broken down on a daily basis it is roughly 602 acre-feet per day (74,000 cubic meters per day). A description of water volume calculations can be found on page 21.

It is anticipated that fall operations may not affect adult starry flounder since adults inhabit coastal and bay waters away from Suisun Marsh. However, in early spring larval and juvenile fish may be present. Based on the CDFG 20 mm trawl catch, whose data stations include Suisun Bay and main stem Montezuma Slough, it is estimated that a range of zero to 2,812 juvenile starry flounder (*37,000 cubic meters of water multiplied by 76 fish per 10,000 cubic meters) [*description of water volume calculations can be found on page 21. This data reflects fish collected in Suisun Bay and main stem Montezuma Slough. While the fish may be present, this region diverts water through screened diversions therefore impacts to the species will be limited. In addition during recent CDFG diversion monitoring studies, juvenile Starry flounders were caught in the latter half of the spring water diversion cycle. This CDFG's sampling efforts caught 143 Starry flounders over the three years of sampling. Most of that catch occurred in one sampling season that resulted in 128 individuals being collected.

<u>Sturgeon</u>

There will be minimal adverse effects to this species of the proposed two-year extension of the General Permit. In Region 1 two green sturgeon were captured in April 1996 and March 1998 as found in the DBAT database for two Goodyear Slough sampling locations. These sampling locations are labeled 410MWT and 412 MWT, both on Goodyear Slough but not the same locations used to report starry flounder occurrence, as those stations did not record the catch of any sturgeon. In Region 2 ten white sturgeon were caught in Suisun Slough, April through December and between 1985 and 1999. In Region 3 two were caught in Nurse Slough in November 1992 and December 1995. In Region 4 three white sturgeon were caught in Montezuma Slough: September 1989, January 1995, and September 1998. This data is in Appendix B. The data reported in the DBAT database cannot be extrapolated to population numbers; however, the data shows trends in species catch both temporally and spatially.

Sampling by DWR at the MIDS intake and in Goodyear Slough has caught no sturgeon during the sampling period: September 23, 2004 to May 26, 2005.

Effects: All in-channel activities will occur at low tide where this species will not be present and the EFH impacts associated with these activities will be minimal. These activities are the first 12 listed in Table 1. After any of these activities fish usage will continue and will not be disturbed.

There may be a temporary EFH adverse impact caused by the installation of brush boxes on levees. Although there will be no in-water work and work will be done entirely by hand there remains the possibility of increased turbidity for a short time.

The effect of dredging at fish screens will be short term. This work will be done at low tide to minimize turbidity plus the diversion will be opened on the incoming tide to draw any turbidity into the managed wetland. There is the potential, however, for a short term adverse effect caused by the removal of habitat used as a feeding substrate. There is not much known about the diet of green sturgeon. White sturgeon caught in San Pablo Bay in 2004 had been feeding on non-native clams and two green sturgeon had nothing in their guts according to Nina Kogut, CDFG Fisheries Biologist at CVDBD. It can be assumed that the siltation that builds up in front of fish screens supports vertebrates and invertebrates that might be used by sturgeon. The impact is hard to quantify as the amount of substrate that is disturbed is small and larger-sized juvenile and adult sturgeon are more likely to be found in the middle of the slough where these impacts would not take place.

There are likely to be no EFH effects for this species by diversion drainage operations in Regions 2-4. This area has much larger sloughs such as Suisun and Montezuma Sloughs with much larger daily movements of water. Additionally some diversions drain directly in the bays where possible. This species is somewhat more likely to be affected by water quality impacts from drainage in Region 1. DWR has monitored the quality of drain water for specific conductance taking limited data on water temperature, dissolved oxygen, and pH levels for these western sloughs and have found pH and temperature of drain water were comparable to slough water and dissolved oxygen levels and appeared sufficient in both drain and slough water. There exists the possibility for seasonal and temporary impacts of "black water" in this zone caused from bacterial decomposition of vegetation under low dissolved oxygen levels. Landowners in this zone have made management modifications to reduce the extent and severity of low DO events and these and these management practices are detailed on page 19.

Entrainment of this species is not expected because the species is benthic and uses the middle area of a slough.

Northern Anchovy

There will be minimal adverse effects to this species of the proposed two-year extension of the General Permit. From the DBAT database we saw that in Region 1 thirteen northern anchovies were caught between 1979 and 2001. In Region 2 there were 1,216; in Region 3 there were 483 anchovies; and in Region 4 no anchovies were caught in surveys. This data is in Appendix B.

The CDFG 20 mm trawls also showed significant numbers of anchovies. These surveys were conducted between March and July of the years 2000 to 2005. Numbers of anchovy caught ranged from a low of zero to a high of 2,927 (expanded catch per 10,000 cubic meters sampled) as shown below:

	Year					
Month	2000	2001	2002	2003	2004	2005

March	0	61	22	0	7	10
April	0	202	26	13	7	0
May	0	656	26	0	32	0
June	51	2,927	343	6	51	
July	113	0	0	170	102	

All in-channel activities will occur at low tide where this species will not be present and the EFH impacts associated with these activities will be minimal. These activities are the first 12 listed in Table 1. After any of these activities fish usage will continue and will not be disturbed.

There may be a temporary EFH adverse impact caused by the installation of brush boxes on levees. Although there will be no in-water work and work will be done entirely by hand there remains the possibility of increased turbidity for a short time.

The EFH effect of dredging at fish screens will be temporary. This work will be done at low tide to minimize turbidity and the diversion will be opened to draw any turbidity into the managed wetland on the incoming tide, therefore the effects will be temporary.

There are likely to be no EFH effects for this species by diversion drainage operations in Regions 2-4. This area has much larger sloughs such as Suisun and Montezuma Sloughs with much larger daily movements of water. Additionally some diversions drain directly in the bays where possible. This species is somewhat more likely to be affected by water quality impacts from drainage in Region 1. DWR has monitored the quality of drain water for specific conductance taking limited data on water temperature, dissolved oxygen, and pH levels for these western sloughs and have found pH and temperature of drain water were comparable to slough water and dissolved oxygen levels and appeared sufficient in both drain and slough water. There exists the possibility for seasonal and temporary impacts of “black water” in this region caused from bacterial decomposition of vegetation under low dissolved oxygen levels. Landowners in this region have made management modifications to reduce the extent and severity of low DO events and these and these management practices are detailed on page 19.

The potential for entrainment of this species is slight. Although the species is caught in abundance as shown in the data above, this was with midwater trawl surveys, an open water survey. This species is much less likely to use near shore habitat therefore less likely to be entrained. This is supported by CDFG’s diversion monitoring study that had 386 sampling days in 1996-1998 with no anchovies caught during this monitoring effort.

<u>Steelhead</u>

The only catch information for steelhead was in the BDAT database. There are only two capture records, one from 1973 and one from 1998, both at Montezuma Slough at Roaring River Slough. The data reported in the DBAT database cannot be extrapolated to population numbers.

Sampling by DWR at the Morrow Island Distribution System intake and in Goodyear Slough has caught no steelhead during the sampling period: September 23, 2004 to May 26, 2005

ESA ASSESSMENT

A majority of the activities described in the permit extension occur outside of the water channel and will not impact the steelhead. The activities that are described below may take some individuals of this species; however we do not believe that the RGP extension and its associated activities will adversely affect the continued existence or health of either the Central California Coast or Central Valley steelhead.

In-channel work activities will occur at low tide when the fish are not present and will be conducted so that disturbance to the surrounding environment is minimized.

Brush box installation will occur outside of the water and hand tools will be used to install the structures. These structures are anticipated to provide an alternative method for levee stabilization without the need for placing riprap or other items to shore up the levee. It is anticipated that installation of these "more natural" methods of levee protection will reduce the accumulation of predatory fish.

Maintenance dredging near currently operating fish screens will increase their efficiency to meet approach velocities by removing silt deposits that are accumulating on the screen surface. There may be some minor increased turbidity levels in the local area when the incoming tide floods the dredged area; however it is believed that this will be very minimal. The diversion will be opened to draw in potential silt activation when the water floods the site.

Currently there is no information, nor a way to accurately calculate the approach velocity of water diversions in the Suisun Marsh. Variable factors such as tide height, head differential, pond elevation, and time of day contribute to a diverse range of potential velocities. However, the potential does exist for the entrainment of steelhead into diversions but CDFG and DWR diversion monitoring efforts have resulted in no capture of juvenile steelhead. In our opinion the potential for diversion entrainment of steelhead is limited and is not expected to have an impact on the steelhead population.

There are likely to be no adverse effects for this species by diversion drainage operations since the two catches occurred at the junction of large sloughs with large daily movements of water.

Chinook Salmon - Winter-, Spring-, and Fall-run

The BDAT database shows salmon occur in Suisun Marsh. From 1980 to 2001 Region 1 had no occurrences of salmon. Region 2, Suisun Slough and Montezuma Slough, had 29 records between 1980 and 2001. Region 3, Montezuma Slough at Roaring River and Montezuma Slough at the Sacramento River, had 573 records between 1980 and 2001. Region 4, lower Denverton Slough and Montezuma Slough at Nurse Slough, had 160

records between 1982 and 2003. The data reported in the DBAT database cannot be extrapolated to population numbers; however, the data shows trends in species catch both temporally and spatially.
In the late 1990s, CDFG conducted a diversion sampling program that monitored selected diversion on Montezuma Slough and Denverton Slough. During the three sampling seasons CDFG conducted over 386 total sampling days with a total catch of 109 salmon (105 fall run sized; 2 spring-run sized; and 2 winter-run sized). It should be noted that 103 of those total salmon caught were fall-run sized yoke fry that were washed down into the system during an extreme outflow event. The majority of the fish caught were in Montezuma Slough diversion locations with 2 salmon caught at a Denverton Slough diversion. For the purposes of this analysis we will assume that all runs of juvenile Chinook salmon may be affected by the implementation of this project.

Sampling by DWR at the Morrow Island Distribution System intake and in Goodyear Slough has caught no Chinook salmon during the sampling period: September 23, 2004 to May 26, 2005

EFH ASSESSMENT

There will be minimal adverse effects to this species of the proposed two-year extension of the General Permit.

All in-channel activities will occur at low tide where this species will not be present and the EFH impacts associated with these activities will be minimal. These activities are the first 12 listed in Table 1. After any of these activities fish usage will continue and will not be disturbed.

There may be a temporary EFH adverse impact caused by the installation of brush boxes on levees. Although there will be no in-water work and work will be done entirely by hand there remains the possibility of increased turbidity for a short time. This increase in turbidity will be minimal and easily dissipate when water mixes with remaining volume of channel.

The EFH effect of dredging at fish screens will be temporary. This work will be done at low tide to minimize turbidity and the fish screen will be opened to draw any turbidity into the managed wetland on the incoming tide.

There are likely to be no EFH effects for this species by diversion drainage operations in Regions 2-4. This area has much larger sloughs such as Suisun and Montezuma Sloughs with much larger daily movements of water. Additionally some diversions drain directly in the bays where possible. This species is somewhat more likely to be affected by water quality impacts from drainage in Region 1. DWR has monitored the quality of drain water for specific conductance taking limited data on water temperature, dissolved oxygen, and pH levels for these western sloughs and have found pH and temperature of drain water were comparable to slough water and dissolved oxygen levels and appeared sufficient in both drain and slough water. There exists the possibility for seasonal and temporary impacts of "black water" in this region caused from bacterial decomposition of vegetation under low dissolved oxygen levels. Landowners in this zone have made management modifications to reduce the extent and severity of low DO events and these management practices are detailed on page 19.

The potential for diversion entrainment of juvenile and, on rare occasions, yoke-sac larvae Chinook salmon is likely to occur and is anticipated to have a low impact on the species as a whole. During CDFG diversion monitoring efforts in the Suisun Marsh during the late 1990s, juvenile salmon from all three runs were caught. During the three years of sampling 109 salmon were caught over the 386 total sampling days. The majority of the salmon caught were fall-run sized salmon (105). Of the 105 fall-run sized salmon caught, 103 of them were yoke-sac larvae that were swept downstream during a high outflow event. Of the remaining 4 salmon caught, 2 were winter-run sized and 2 were spring-run sized Chinook salmon. The diversion of Chinook salmon occurred throughout the Suisun Marsh and was not limited solely to Montezuma Slough.

The likelihood of entrainment of salmon in Region 4 is greatly reduced by the percentage of land that is flooded by screened diversions. Overall in the Marsh the potential for entrainment is reduced by the diversion restrictions. There are restrictions to protect winter-run adult salmon during November through January, a time when some clubs are circulating water in the clubs. There are restrictions from mid-February to April to protect winter-run juvenile salmon, a time when winter flood up and circulation is taking place. There exist restrictions from mid-April to October as part of the BCDC restrictions. For descriptions of these restrictions see the write-up under Permit Conditions – Salmon Closures that begins on page 28.

ESA ASSESSMENT

A majority of the activities described in the permit extension occur outside of the water channel and will not impact the salmon. The activities that are described below may take some individuals of this species; however we do not believe that the two-year extension of the General Permit and its associated activities will adversely affect the continued existence of either the Winter- or the Spring-run Chinook salmon.

In-channel work activities will occur at low tide when the fish are not present and will be conducted so that disturbance to the surrounding environment is minimized.

Brush box installation will occur outside of the water and hand tools will be used to install the structures. These structures are anticipated to provide an alternative method for levee stabilization without the need for placing riprap or other items to shore up the levee. It is anticipated that installation of these "more natural" methods of levee protection will reduce the accumulation of predatory fish. Reductions in predatory fish species could reduce losses of out migrant juvenile salmon species when passing through the Suisun Marsh.

Maintenance dredging near currently operating fish screens will increase their efficiency to meet approach velocities by removing silt deposits that are accumulating on the screen surface. There may be some minor increased turbidity levels in the local area when the incoming tide floods the dredged area; however it is believe that this will be very minimal. The diversion will be opened to draw in potential silt activation when the water floods the site.

There are likely to be no adverse impacts on Chinook salmon by diversion drainage operations in Regions 2-4. This area has much larger sloughs such as Suisun and Montezuma Sloughs with much larger daily movements of water. Additionally some diversions drain directly into the bays where possible. Chinook salmon are somewhat more likely to be affected by water quality impacts from drainage in Region 1. DWR has monitored the quality of drain water for specific conductance taking limited data on water temperature, dissolved oxygen, and pH levels for these western sloughs and have found pH and temperature of drain water were comparable to slough water and dissolved oxygen levels and appeared sufficient in both drain and slough water.   There exists the possibility for seasonal and temporary impacts of “black water” in this region caused from bacterial decomposition of vegetation under low dissolved oxygen levels. Landowners in this zone have implemented best management practices to reduce the extent and severity of low DO events and these management practices are detailed on page 19.

For entrainment impacts see write up in EFH analysis.

Appendix F

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