Delta Islands and Levees Feasibility Study

Monitoring and Adaptive Management Plan

September 2018

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ACRONYMS AND ABBREVIATIONS

CDFW	California Department of Fish and Wildlife
CWA	Clean Water Act
DWR	Department of Water Resources
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
GPS	global positioning system
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
RWQCB	Regional Water Quality Control Board
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1.0 INTRODUCTION

This document outlines the feasibility level monitoring and adaptive management plan (MAMP) for the Delta Islands and Levees Feasibility Study (Delta Study) in Contra Costa County, California. The U.S. Army Corps of Engineers (USACE), in ongoing cooperation with the non-Federal study sponsor, the California Department of Water Resources (DWR), has developed this plan to describe monitoring and adaptive management activities proposed for the Delta Study, assign costs, and estimate duration. Monitoring and adaptive management addresses sources of uncertainty, steers project implementation and maintenance to ensure that the intended project benefits are attained, and documents project effects for communication to participants and stakeholders.

1.1 Authorization for Adaptive Management for the Delta Study

This MAMP is prepared following the 19 Oct 2017 Implementation Guidance for Section 1161 of the Water Resources Development Act of 2016 (WRDA 2016), Completion of Ecosystem Restoration Projects. Following the Implementation Guidance, this MAMP will list the physical actions to be carried out; contextualize those actions with their functions and ecological outputs; describe the success criteria for the actions; list the means, methods, and frequencies of monitoring for success; list adaptive management measures along with the triggers for implementation of each measure; and establish costs for implementation of the MAMP.

Concurrence by the non-Federal sponsor and cost-shared funding would be needed to implement adaptive management. Any changes to the adaptive management plan in the approved feasibility report must be coordinated with HQUSACE. Significant changes to the project required to achieve ecological success which cannot be appropriately addressed through operational changes or through the approved adaptive management plan may need to be examined under other authorities, such as Section 216 of the River and Harbor and Flood Control Act of 1970.

This plan would be authorized by any future Congressional authorization issued for the Delta Study's Chief's Report.

1.2 Adaptive Management Team Structure

As part of the communication structure for implementation of adaptive management, an Adaptive Management Planning Team will be established. This team will be led by a Senior Planner or Senior Environmental Manager from USACE and may include a counterpart from DWR. Other resources and expertise will be brought in as needed, and may include other representatives from USACE, DWR, the East Bay Regional Parks District (EBRPD), the California Department of Fish and Wildlife (CDFW), the U.S. Fish and Wildlife Service (USFWS), or National Marine Fisheries Service (NMFS). This team is responsible for ensuring that monitoring data and assessments are properly used in the adaptive management decision-making process. If this team determines that adaptive management actions are needed, the team will coordinate a path forward with project planners and project managers. The Adaptive Management Planning Team is also responsible for project documentation, reporting, and external communication.

1.3 Background

The Delta Study was initiated by USACE in 2006 at the request of DWR, the non-Federal sponsor for the study. USACE is the lead agency for the Feasibility Study and is also the lead under NEPA. DWR is the lead agency under the California Environmental Quality Act (CEQA).

The Delta (Figure 1) is part of the largest estuary on the West Coast of the United States; is home to hundreds of species of fish, birds, mammals and reptiles; and is considered an ecosystem of national significance. Agricultural land irrigated by Delta water contributes billions of dollars in production for the Nation. Two deep water ports in the Delta serve as important marine terminals for vessels transporting products through the Delta's deep draft navigation channels to world markets. Delta levees protect thousands of acres of orchards, farms, and vineyards as well as critical infrastructure including state and interstate highways, major rail lines, natural gas fields, gas and fuel pipelines, water conveyance infrastructure, drinking water pipelines, and numerous towns, businesses and homes.

The Delta is a web of channels and reclaimed islands at the confluence of the Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers. Forty percent of California's land area is contained within the watersheds of these rivers. The Delta covers about 738,000 acres and is interlaced with hundreds of miles of waterways. Much of the land is below sea level and protected by a network of 1,100 miles of levees which have been constructed over the past 150 years to manage the flow of water through the Delta. The land behind the levees is predominantly agricultural (corn, wheat, vineyards, cattle) and waterways provide recreational outlets for nearby urban areas and important habitat for fish and wildlife, including Federally listed species under the Endangered Species Act. The Delta is also the largest single source of California's water supply, providing 25 million Californians with drinking water and irrigating millions of acres of farmland in the Central Valley. In addition, more than 500,000 people live within the Delta and rely upon it for water, recreation, and livelihood. The majority of that population is in the greater Sacramento and Stockton areas and is the focus of other USACE Flood Risk Management studies, though there are communities within the Delta. Several Delta towns, known as "legacy communities," are listed in the National Register of Historic Places.

Historically, the Delta was defined by tidal wetlands, primarily comprised of peat soils. The Swamp and Overflow Land Act of 1850 transferred ownership of all Federally owned swamp and overflow land, including Delta marshes, from the Federal Government to private parties agreeing to drain the land and turn it to productive, presumably agricultural, use. This Act began the reclamation of wetlands in the Delta through the construction of levees and drainage channels, typically by the new land owners. The majority of levees in the Delta are still privately owned and maintained. Nearly three fourths of the Delta is now in agriculture.

1.4 Project Location

The original study area (Figure 1) included the entire Sacramento – San Joaquin Delta and Suisun Marsh, comprising parts of Sacramento, San Joaquin, Solano, Contra Costa, Alameda, and Yolo Counties, California. The plan formulation process focused the study area resulting in a final array of alternatives that includes intertidal marsh restoration sites at Big Break, Franks Tract, and Little Franks Tract. The selected plan would result in 340 acres of restored intertidal marsh habitat at Big Break, created through the beneficial reuse of approximately one million cubic yards of dredged material directly placed from yearly Operations and Maintenance dredging of the Stockton Deep Water Ship Channel (DWSC). As a result, the final study area includes Big Break, Jersey Island, and the adjacent portions of the Stockton DWSC. This area is located within Contra Costa County.

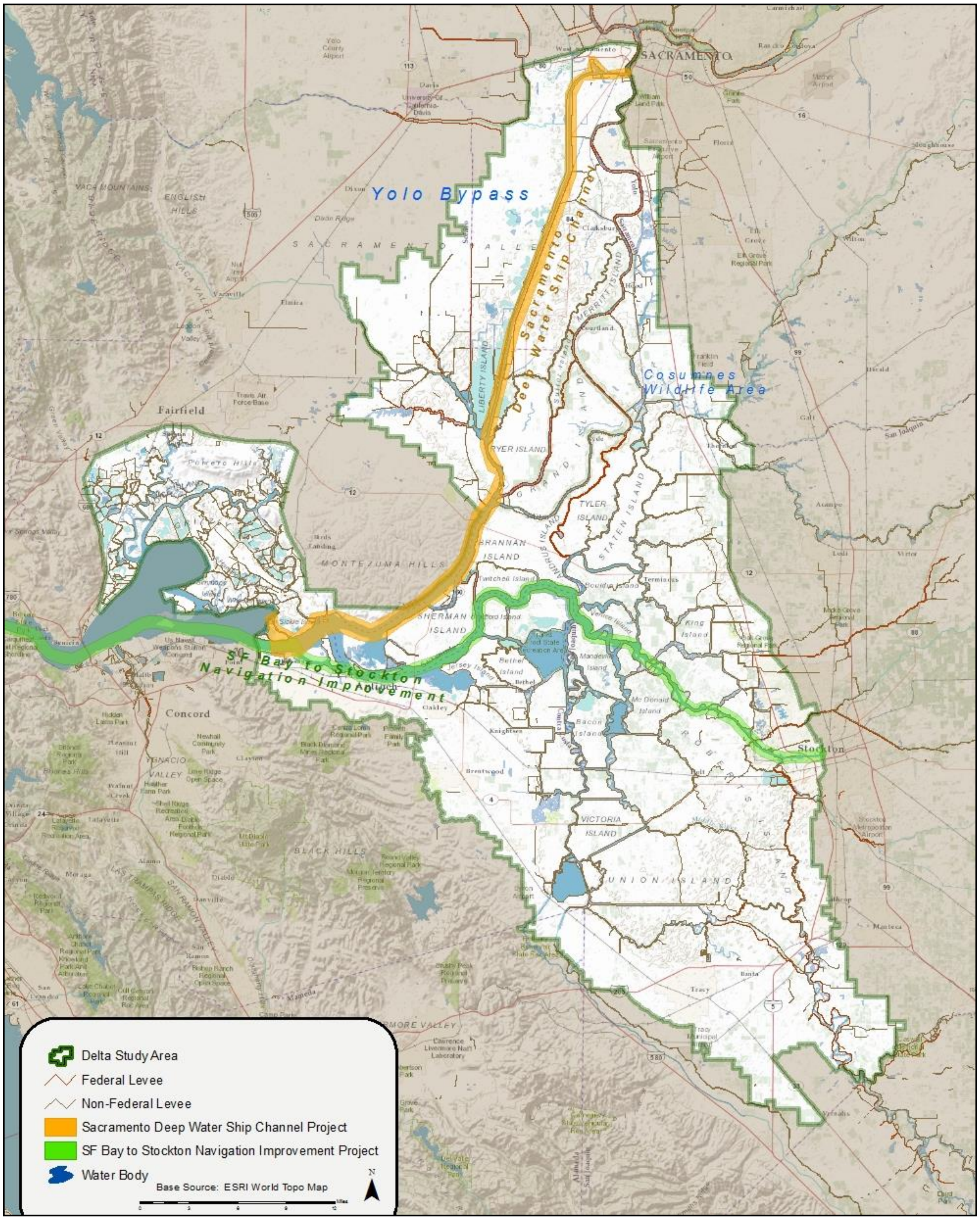

Figure 1. The Delta Study Area

2.0 PROJECT DESCRIPTION

2.1 Planning Objectives

The planning objectives, which are developed specifically for this study, are statements of the study purpose. Planning objectives are more specific than the Federal and non-Federal objectives and reflect the problems and opportunities in the Delta Study area; an objective is developed to address each of the identified problems and opportunities. Planning objectives represent desired positive changes in the future without-project conditions. The planning objectives for the Delta Study would be attained within the period of analysis for the study, a 50-year timeframe beginning in 2020, pending identification of Federal interest and inclusion in a selected plan. All of the objectives focus on activity within the study area.

Goal 1 - Restore sustainable ecosystem functions in the Delta.

- Ecosystem Restoration Objective 1—Increase area, connectivity, and diversity of native tidal and non-tidal aquatic, riparian, and related habitats within the study area during the period of analysis.

2.2 Conceptual Ecological Model (CEM) for Monitoring and Adaptive Management

As part of the planning process, SPK developed a conceptual ecological model to represent current understanding of ecosystem structure and function in the study area (Figure 2). The CEM was used in this MAMP to support the identification of success criteria and help select parameters for monitoring. The model illustrates the effects of important natural and anthropogenic activities that result in different ecological stressors on the system. The model has helped to identify hypothesized effects of restoration actions on selected performance measures defined for broader physical, chemical, and biological attributes of the system.

2.3 Project Description

The selected plan proposes approximately 340 acres of intertidal marsh restoration at Big Break via direct placement of 1,000,000 cubic yards of material from annual O&M dredging over an estimated 10-year period and is both the Selected Plan and the Environmentally Preferred Alternative. Dredged material would come from O&M activities in the San Francisco Bay to Stockton DWSC between approximately station points 400+00 and 850+00 (Figure 3). Dredged material would be directly pumped to the restoration site, rather than typical land-based dredged material placement sites. Approximately 340 acres of open water habitat would be restored to intertidal marsh habitat, with approximately 90 acres planted with aquatic vegetation. The remaining 245 acres would be underwater channels and shallow habitat for aquatic fauna species. In addition, the 50 acre remnant levee along the northern edge of Big Break would be treated for invasive plant species and would be planted with native riparian species.

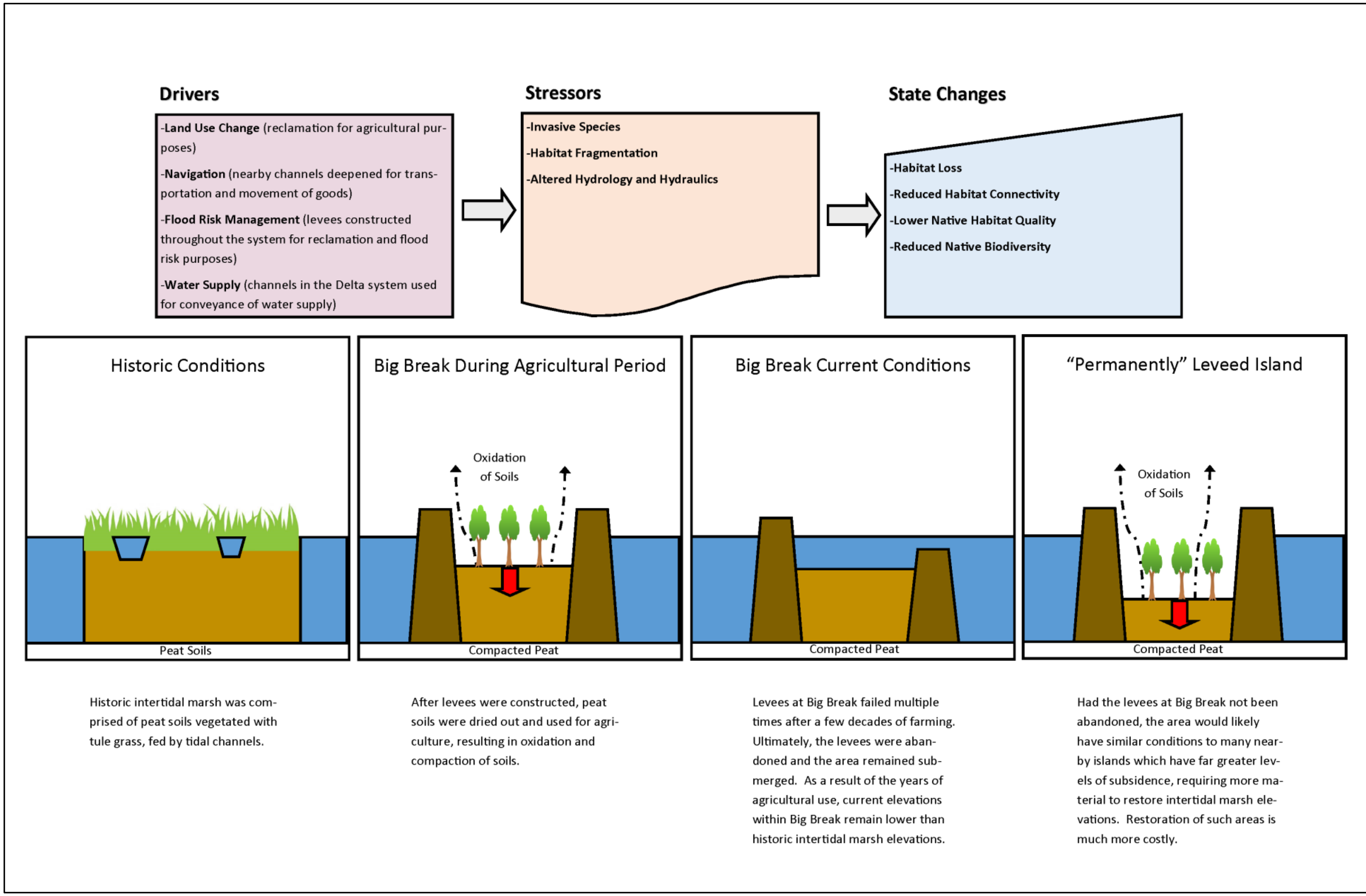

Figure 2. Conceptual Ecological Model

The proposed action includes the redirection of the hydraulic pumping pipeline from the Stockton DWSC to Big Break, including the placement of the pipeline across approximately 0.5 mile of Jersey Island. The proposed action additionally includes the placement of dredged material into Big Break, vegetation installation at the restoration area, associated long-term maintenance actions, and monitoring and adaptive management. Placement would occur over an estimated ten year period in the timeframe of August 1 to November 30, consistent with current and anticipated avoidance work windows for Delta smelt and salmonids as established in the Biological Opinions for the Stockton DWSC dredging. The dredging operations are expected to be conducted 24 hours per day, 7 days per week. It is estimated that approximately 100,000 cubic yards of material would be available in a given year, which would result in the creation of approximately 17 sand mounds per year. Placement at Big Break under the Delta Study is estimated to occur over approximately 15 days per work year.

Dredged material would be pumped from the dredging vessel directly to Big Break. Materials would be pumped to the proposed project areas through a floating 18 inch double wall high density plastic extrusion (HDPE) pipe. The piping system would be placed along the shoreline of the Stockton DWSC in the San Joaquin River. The pipeline would be submerged and anchored to the bottom to avoid navigation hazards. A floating diesel repeater pump station would be positioned approximately every 5,000 feet as necessary to aid slurry flow; pump(s) would be installed on a floating platform with stakes to secure its position. Work boats would install and maintain the floating pipeline. An additional work boat and crew would tender the position of the outfall slurry pipe during pumping operations to ensure correct placement of materials.

The pipeline would access Big Break from the DWSC via a land-based crossing at Jersey Island. There is one dirt farm road running north/south on Jersey Island; the pipeline would be placed adjacent to the road above ground. Prior to installation of the pipeline, the dirt road would be improved for vehicular access and hauling. Gravel would be placed on the road at a width of 25 feet. After the haul road is improved, the pipe would be installed by placing 60-foot segments of pipe and welding the segments together. The pipeline would take 1 day to install each construction season and 1 day to remove. The removal process would be the same as the installation process. A 12 person work crew could complete this task in a 12 hour work day.

The pipeline would cross one farm road running east/west, in addition to two levee roads on the north and south shore of the island. Above-ground, culvert-style crossings would be installed at these intersections in order to avoid impacts to the farm fields. The proposed crossing location is shown on Figure 3-14 above. The Jersey Island crossing is not anticipated to need a booster pump on the island; however, a floating booster pump station would likely be installed adjacent to the north shore of Jersey Island.

In addition, a 1-acre staging area would be used each year on Jersey Island. The staging area would be located on the south shore of Jersey Island at the end of the haul road and pipeline crossing. The staging area would be improved, as needed, by placing gravel for vehicular use.

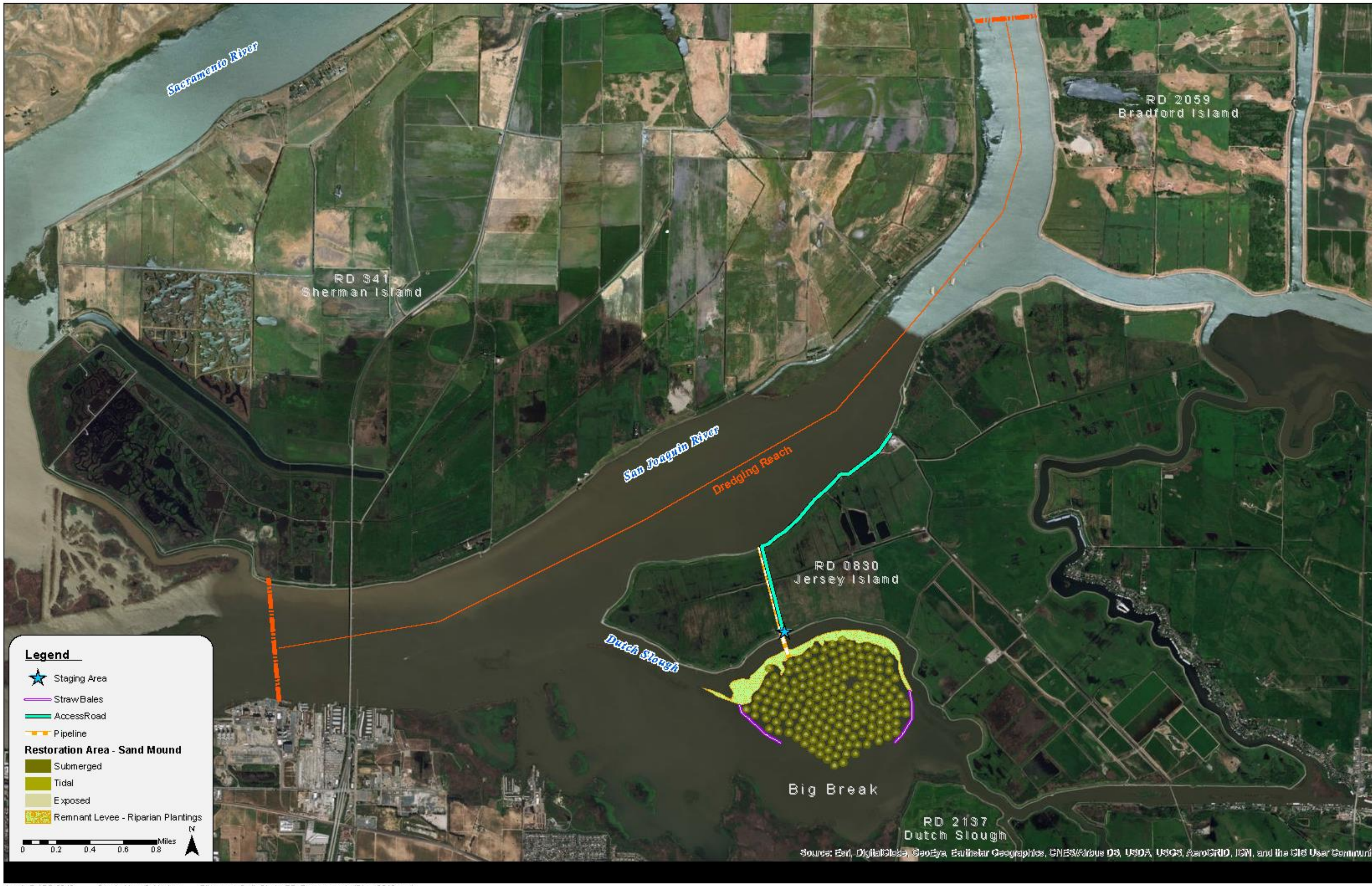

Figure 3. Selected Plan

Material Placement

The hydraulic slurry would be discharged at the restoration sites at an assumed average rate of 450 cubic yards per hour or 8,100 cubic yards per day. Placement of the material will occur using baffle plates to dispel the energy and direct the sediment downwart to create quasi-symmetrical sand mounds. Analysis of over 10 years of grain size distribution data for the 400+00 to 850+00 dredging reaches shows the material to be virtually completely fine sand. Since this sand will be falling in a hydraulic slurry, the sand is assumed to settle to a 1 on 20 slope below the mean tide level (MTL, which is 2 feet higher than the mean lower low water [MLLW] level) and to a 1 on 10 slope above the MTL. This placement process is similar enough to sand depositing in the navigation channel that no bulking of the placed dredged material is assumed and no consolidation of the placed material is assumed (i.e. one cubic yard taken from the channel is equal in volume to one cubic yard of a placed sand mound).

Sand mounds would be placed so that the mound toes do not overlap, leaving channels of varying sizes between the mounds. The intent is to ensure that the channel centerlines are never shallower than the existing condition (-3 to -4 feet MLLW). The goal of this placement plan is to create a diverse habitat that provides value to both shallow water aquatic fauna that require varying depths of soft bottom habitat, as well as terrestrial marsh species such as shore birds. In addition, based on lessons learned from Donlon Island, this design is intended to provide sufficient flow through the site to maintain water quality. A larger channel will be identified through the restoration site in the preconstruction engineering and design phase to provide a kayak trail to minimize the loss of recreational opportunities in the restoration footprint.

The bed material at Big Break is former agricultural land that was prone to subsidence upon drying, thus the material is assumed to be highly compressible. Table 3-19 lists assumptions that are thought to be reasonable but conservative for the compression of Big Break bed materials beneath hydraulically placed sand.

Table 1. Assumed Consolidation of Big Break Bed Sediments and Other Assumed Sand Mound Losses

Depth Interval		Assumed Placement Slope	Consolidation of Big Break Floor	Erosional/ Consolidation/ SLR losses
above MHHW		1 on 10	0 foot	1 foot
MTL	MHHW	1 on 10	2 feet	none
MLLW	MTL	1 on 20	1 foot	none
bottom	MLLW	1 on 20	none	none

In addition to “losses” of placed dredged material by the compression of underlying sediments (as a greater volume of sand is necessary to construct a mound of a given height above the sediment bed), other potential losses that could occur include:

- Wave wash erosion during storms;
- Unpredicted consolidation in excess of assumed amounts; and,

- Ineffective elevations due to sea level rise (SLR).

Table 3-19 also indicates a contingency amount of 1 foot of additional mound height losses due to some combination of these factors. Figures 3-16a and 3-16b display the initial placement (black line) and final geometry (red line, used for plantable area sizing calculations) of a sand mound placed at -3 feet MLLW and -4 feet MLLW, respectively. It is estimated that the sand mounds would require approximately 10 months for settlement following construction. Following the settlement period, aquatic vegetation would be installed, as described below.

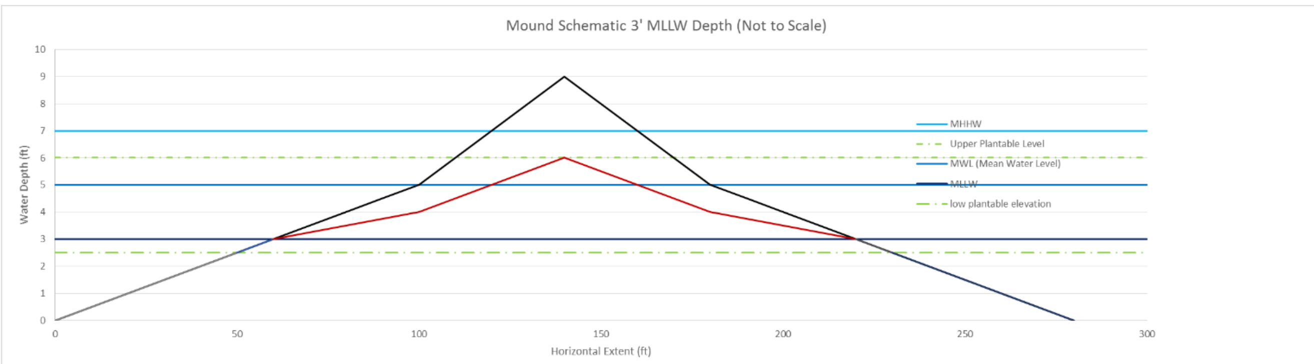

Figure 3. Initial and Final Assumed Sand Mound Geometry at -3 feet MLLW

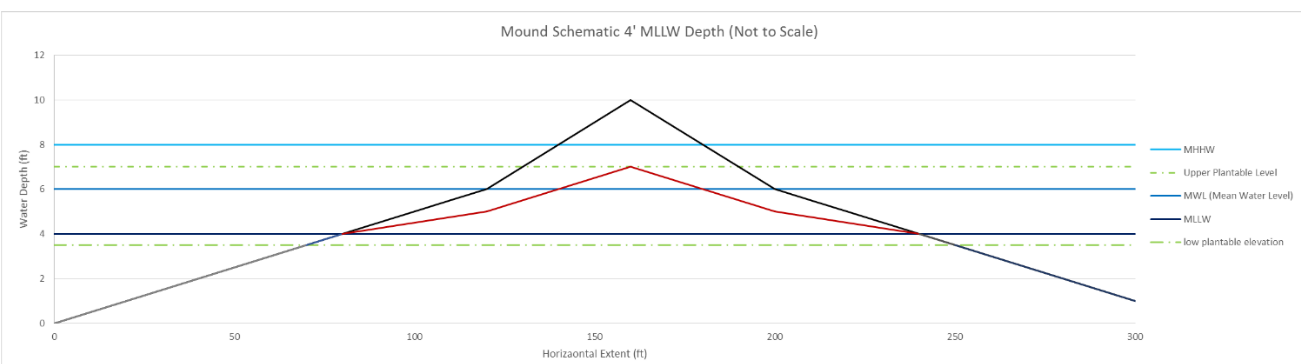

Figure 4. Initial and Final Assumed Sand Mound Geometry at -4 feet MLLW

Sacrificial straw bales will be placed to provide barriers to the predominant flow paths to allow for sediment settling and sand mound stability. Straw bales are anticipated to persist 1 to 2 years, giving sufficient time for vegetative establishment, after which vegetation is assumed to provide adequate erosion resistance. Sacrificial straw bales would be used to aid in compliance with water quality requirements. Straw bale lines are not anticipated to be fully enclosing; however, should enclosure become a possibility, the top of the sacrificial straw bale line would be set at mean low tide level to allow fish an opportunity to escape the work area. If unanticipated quantities of fine-grained material are present in dredged sediments, turbidity curtains can be used in combination with sacrificial straw bales and would float slightly above the bottom allowing aquatic species to escape entrapment.

The bed level within the proposed footprint varies from -3 to -4 feet MLLW; mean tides within Big Break range from 0 feet MLLW to +4 feet MLLW. As a result, bed depths in the restoration area range from 3 feet during a mean lower low water tide to 8 feet during a mean higher high water tide.

The proposed sand mounds would be constructed with a target elevation of +3 feet MLLW. Thus at high tide, sand mounds will be approximately 1 foot below the water surface level; and at low tide, the top of the vegetated sand mounds would be exposed.

Construction of the sand mounds would require approximately six workers. Approximately 12 employee trips per day of 20 miles each way would be typical for access to and from the site. Equipment anticipated for construction includes three generators/motors, one lift pump, and two work boats.

Plantings

Plantings would be installed during two separate periods: the aquatic vegetation would be installed in the spring and the terrestrial vegetation would be installed in the fall. Following planting is the initial establishment period, which starts when all the plants have been installed and accepted. The establishment period would be for three continuous years. Seed collection would occur in the spring or summer. The seeds would then be propagated in a nursery for approximately 1 year prior to installation. Table 3-20 identifies species generally conductive to the project region.

Table 2. Terrestrial and Aquatic Plant Species Native to the Study Area

Botanical Name	Common Name	Botanical Name	Common Name
Salix exigua	Sandbar willow (terrestrial)	*Schoenoplectus californicus*	California bulrush (aquatic)
Salix lasiolepis	Arroyo willow (terrestrial)	*Artemisia douglasiana*	Mugwort (terrestrial)
Salix gooddingii	Black willow (terrestrial)	*Baccharis salicifolia*	Mule fat (terrestrial)
Alnus rhombifolia	White alder (terrestrial)	*Rubus ursinus*	California blackberry (terrestrial)
Populus fremontii	Fremont cottonwood (terrestrial)	*Rosa californica*	California wildrose (terrestrial)
Acer negundo	Box Elder Maple (terrestrial)	*Schoenoplectus tabernaemontani*	Soft bulrush (aquatic)
Cephalanthus occidentalis	Button willow (terrestrial)		

<u>Riparian Planting</u>

Prior to construction, the existing remnant levee would be treated to remove existing invasive vegetation. Invasive vegetation would be removed using a gas-powered hedger. The cuttings would be raked-up using pitchforks, and the cuttings would be chipped. The chips would be spread over the ground as mulch. The exposed residue rootstock would be treated with three treatments of herbicide, spaced one month apart. The herbicide would be approved for use near water bodies. This treatment is necessary to ensure the desirable planted grass and terrestrial vegetation would establish without competition. This would give the desirable vegetation a head start, and make it harder for the undesirable vegetation to return. Native grass would be seeded following initial invasive removal to provide both habitat and soil stabilization while the remnant levee is being monitored to ensure that the invasive treatment is successful. Invasive treatment of the remnant levee is anticipated to occur the summer before the first dredged placement occurs.

Terrestrial riparian species would be planted in the fall of the first construction season on the remnant levee at 235 plants per acre, protected and maintained for 3 years until their roots have established. Ground water is relatively close to the ground level, so survival is expected to be high and would easily achieve a goal of 141 plants per acre, or 60% of all installed plants. The ultimate goal is to promote root growth and enable the plants to achieve self-sufficiency by the end of the 3 year establishment period. The plantings are considered self-sufficient when a plant is developed and adapted sufficiently to its setting and is able to sustain itself in its current environment without artificial or human support.

Terrestrial riparian planting would be installed by a crew of up to eight workers for 12 hour work days. Equipment needs for riparian planting, establishment, and monitoring is estimated to include a boat, a truck, a hedger, a tractor, and a weed whacker.

Aquatic Planting

Following dredged material placement and the 10-month settlement period, vegetation would be installed on the sand mounds annually. Based on experience from the nearby Donlan Island restoration project, the plantable zone on the placed sand mounds is assumed to be from -2.5 to + 1 feet MTL (or, -0.5 to +3 MLLW). Desirable aquatic vegetation would be planted to pioneer a source for colonization before undesirable exotic vegetation could develop. The plant material may be nursery grown or collected from nearby sources and directly planted at the site. For the purposes of this analysis, it is assumed that the plant material would be nursery grown.

Bulrush (*Schoenoplectus* spp.) and cattail (*Typha* spp.) are two desirable prominent aquatic species that are expected to colonize the mounds. Other aquatic species to be planted are rushes, sedges and spike rushes. However, since cattail is a dominate colonizer and bulrush is slow to colonize, bulrush will be planted to give it a head start. Ten percent of the target area would be planted with bulrush spaced at 3 feet on center, which averages out to approximately 45 plants per acre, with natural recruitment assumed over time. Bulrush will be installed in the mid elevation of the aquatic planting elevation zone.

Aquatic plant installation would be conducted using a crew of approximately 4 workers. Equipment needs are estimated to require 2 boats and a truck for approximately 11 days of work (standard daylight work hours) each planting year.

3.0 MONITORING AND ADAPTIVE MANAGEMENT PLAN

This section will describe the monitoring, assessment, and decision making processes that form the basis of adaptive management. This section will establish conceptual habitat restoration proposals, performance standards, and outline adaptive management measures and costs. Conceptual habitat restoration proposals are based on the project goals and objectives described above. Success criteria include specific feature(s) to be monitored to determine project performance. Success criteria are established below for each habitat type, and monitoring would be conducted with the intent of meeting those standards. Adaptive management measures are actions identified to address potential mechanisms for failure of project features meeting performance criteria. Triggers for implementation of adaptive management measures are established below for each habitat type.

Monitoring must be closely integrated with all other adaptive management components because it is the key to the evaluation, validation, and learning components of adaptive management. Over the 3 year site establishment period, improvements in field and analytic techniques may lead to changes in the monitoring methodology. Furthermore, unrealistic expectations or inaccurate assumptions can lead to the establishment of inappropriate monitoring objectives. It is possible that a decision to modify success criteria might be reached based on results after several years of monitoring. In the future, once a determination has been made that specific success criteria have been met, associated monitoring tasks would cease. Similarly, it could be determined that a monitoring task is not returning useful information, and therefore not worth the expense of continuation. When possible, specific monitoring and large scale information needs should be integrated with existing monitoring efforts that are underway in the Delta. During the PED phase the PDT will explore opportunities to collaborate with existing monitoring networks to achieve the monitoring objectives associated with this project.

Monitoring for ecological success and adaptive management for the project would be initiated upon completion of each construction season and would continue until ecological success is achieved, as defined by the success criteria established below. This monitoring plan includes the minimum monitoring actions to evaluate success and to determine adaptive management needs. Although the law allows for up to ten years of cost-shared implementation of the monitoring plan, ten years of monitoring may not be required. Once ecological success has been documented by the District Engineer in consultation with the Federal and State resource agencies, and a determination has been made by the Division Engineer that ecological success has been achieved, which may occur in less than ten years post-construction, no further monitoring would be performed. If success cannot be determined within that ten-year period of monitoring, any additional monitoring would be a non-Federal responsibility. This plan estimated monitoring costs for a period of 15 years, in some cases, because the monitoring accounts for the 10 year construction period and a 5 year post-construction monitoring period. A timeline displaying the construction and monitoring assumptions is shown in Table 3 below.

Table 3. Construction and Monitoring Estimated Timeline

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15
Placement 1															
Placement 2															
Placement 3															
Placement 4															
Placement 5															
Placement 6															
Placement 7															
Placement 8															
Placement 9															
Placement 10															
Riparian Planting															
Water Quality															
Annual Reports															
Index	Construct		Plant		Establish		Monitor		Reports						

Following successful establishment of project features, the project would be maintained by the non-Federal sponsor as required by the Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) manual. As specified by Section 1161 of WRDA 2016, the requirement for operation and maintenance of the nonstructural and nonmechnical elements of the project by the non-Federal sponsor will cease ten years after ecological success has been determined.

Ecosystem restoration would occur through restoration of Sacramento-San Joaquin River Delta (Delta) native tidal and non-tidal aquatic, riparian, and related habitats via increased area, connectivity, and diversity at Big Break. There are three physical actions being undertaken in order to achieve project objectives:

- Dredged material placement;
- Riparian planting; and,
- Aquatic planting.

The following discussion outlines key components of a monitoring plan that will support the Delta Study. The plan identifies success criteria, along with desired outcomes and monitoring designs in relation to specific project goals and objectives associated with these three physical actions.

3.1 Dredged Material Placement

3.1.1 Objectives and Implementation Strategy

Dredged material consisting predominately of fine sand will be placed in mounds on approximately 340 acres within Big Break. Placement of approximately 100,000 cubic yards would occur per construction season, creating about 13 to 17 sand mounds over about 15 days of dredging during the period from August 1 to November 30. This process is estimated to occur over 10 construction seasons, for an estimated total of 1 million cubic yards of dredged material.

The primary objective of dredged material placement in Big Break is to increase ground surface elevations that historically subsided to a more natural condition, allowing for the restoration of tidal marsh habitat. Functions that would result from creation of the sand mounds would include improving fish habitat, restoring vegetated marsh habitat, restoring habitat for shore birds, and promoting fine sediment accretion.

The settling period for the sand mounds is anticipated to be approximately 10 months following placement of dredged material. This settling period is intended to account for settling following placement and any associated changes in elevation. Following the 10 month settling period, aquatic vegetation would be installed on the sand mounds.

3.1.2 Success Criteria

Monitoring of sand mounds would focus on the physical characteristics of the overall intertidal marsh habitat. The sand mounds would be considered successful if the following criteria are met: (1)

at least 75% of baseline acreages at each target depth interval are present and (2) at least 25% of the total acreage of channels established are passable by fish at a target elevation of -3 feet MLLW. The channels would be defined by any portion of the marsh that has depths in the range of -4 feet to -2 feet MLLW, with a target elevation of -3 feet MLLW. Any marsh footprint with an elevation greater than -2 feet MLLW would be considered part of the sand mounds.

3.1.3 Monitoring Strategy

Physical monitoring of the sand mounds would occur annually, with additional monitoring occurring after any major storms or high water events, as needed. Physical monitoring would involve a survey crew assessing the site by boat or canoe, and measuring depths and elevation levels using a depth finder. Annual monitoring would occur in conjunction with the annual vegetation monitoring, as well as in conjunction with dredged material placement in the following year. If significant issues are noted in the annual monitoring, plans for placement would be adjusted on a year-by-year basis to apply lessons learned and maximize the potential for success.

Success would be determined once the marsh habitat has met the physical success criteria described above for three consecutive years. If the triggers described below are met, then the adaptive management measures described below would be applied to ensure that the physical characteristics of the habitat are successful.

Water quality monitoring would also occur during construction and post construction. Water quality monitoring results would not play into the success criteria, but rather would be used as an adaptive management trigger. Water quality monitoring would occur by installing remote sondes with transmitters at established sites in and around the restoration area on buoys. The sondes would take hourly readings of water quality parameters, such as temperature and dissolved oxygen, to ensure that the restoration site has sufficient water circulation. Other parameters would be added, as needed, for the purposes of water quality compliance under Section 401 of the Clean Water Act. The data collected by the sondes would be assessed by USACE environmental engineers, in comparison with water quality conditions at a nearby reference site, to ensure monitoring compliance or the need for additional measures. The reference site would be determined prior to initiation of construction and would have a similar water quality condition to the estimated future intertidal marsh restoration site.

3.1.4 Adaptive Management Strategy

If monitoring results show that the sand mounds are not meeting the success criteria established above, then adaptive management would be implemented in order to ensure that the habitat restoration is successful. The following subsections identify triggers that would indicate the need to implement adaptive management measures and the measures that would be implemented accordingly to ensure long term success.

Adaptive Management Triggers

- Desired Outcome: Channels exist to reduce potential stranding of fish and increase water circulation through the restoration site.

Trigger: Elevation depth shallower than -2 feet MLLW for 75% of planned channel areas or channel cutoff areas are observed.

- Desired Outcome: Ensure that water quality remains stable or improved from reference site conditions and that the restoration site has sufficient water circulation.

  Trigger: Water quality parameters are lower than 90% of the reference site conditions.

Adaptive Management Measures

If the triggers established above occur, the following measures would be implemented for the sand mounds in order to adaptively manage the site for success.

If the elevation depth is suboptimal, then the following measures would be implemented, as needed:

- First, USACE would analyze nearby meteorology, gages, and velocity trends to determine if there are potential background causes of the elevation changes. This analysis would not be part of annual monitoring, but would be the first step in the adaptive management process if sand mound triggers for adaptive management are met.
- If data shows that there is a velocity issue causing excessive movement of the sand mounds, then additional straw bales could be placed in flow paths to redirect flows and improve circulation.
- If necessary, restoration area could be reshaped through additional excavation to redirect channel flows or additional sediment placement in order to reestablish successful elevation levels. Excavation would involve using a high-pressure pump and pipe/hose to push sediment around. It would not be possible to remove sediment from the site, but rather to reshape the sediment into a more desirable form.
- If some channels are determined to be unsuccessful and cannot be rehabilitated for success, some channel features could be abandoned and filled during the next placement season to establish the target elevation for more functional habitat.

3.2 Riparian Planting

3.2.1 Objectives and Implementation Strategy

A combination of Sandbar willow (*Salix exigua*), Arroyo willow (*Salix lasiolepis*), Black willow (*Salix gooddingii*), White alder (*Alnus rhombifolia*), Fremont cottonwood (*Populus fremontii*), Box elder (*Acer negundo*), and Button willow (*Cephalanthus occidentalis*) would be planted along approximately 6,000 feet of Big Break's remnant northern levee, of which approximately 50 acres remains above water (i.e. a terrestrial environment). Terrestrial planting is anticipated to occur during the first year of the project.

The objective for planting riparian vegetation along the remnant levee is to eradicate the existing invasive vegetation on the remnant levee to ensure that it does not out-compete the new native vegetation associated with the restoration project.

The riparian restoration site may require fencing to protect establishing habitats from recreation, wildlife, and other potential damages. The site would be irrigated during the initial establishment period (approximately 3 years), and would be watered as needed until the riparian vegetation is established and self-sustaining.

3.2.2 Success Criteria

Monitoring of riparian habitat would focus on the percent cover of native species versus non-native species. The riparian habitat would be considered successful when the percent cover of non-native species has remained less than 10% of the total vegetation on the remnant levee for three consecutive years.

3.2.3 Monitoring Strategy

The following monitoring procedures will provide the information necessary to evaluate the success of riparian habitat restoration. Vegetation sampling will occur annually for the duration of the monitoring period. Sampling will occur during spring months, at the peak of growing season. Monitoring would involve a one day drone flyover of the habitat and a biologist assessment of the resulting video. In addition, during boat surveys of the sand mounds, a visual assessment of the perimeter of the remnant levee would occur to supplement the assessment. Monitoring will estimate percent cover of native and non-native plant species

General observations, such as fitness and health of plantings, native plant species recruitment, and signs of drought stress would be noted during the surveys. Additionally, potential soil erosion, flood damage, vandalism and intrusion, trampling, and pest problems would be qualitatively identified. A visual check of irrigation infrastructure and fencing would also be conducted. A general inventory of any wildlife species observed and detected using the restoration site would be documented. Nesting sites and other signs of wildlife use of the newly created habitat would be recorded.

Monitoring reports documenting the restoration effort would be prepared following the first monitoring period and would continue annually until the site has met the success criteria. Monitoring reports would include photos, the timing of the completion of the restoration, what materials were used in the restoration, and plantings (if specified). Monitoring reports would also include recommendations for additional adaptive management measures, if necessary. Following the monitoring period, any subsequent monitoring activities would be the responsibility of the local maintaining agency, and would focus primarily on general and biological inspections for the purposes of fire management and habitat evaluation.

3.2.4 Adaptive Management Strategy

If the habitat is not meeting the success criteria established above, then adaptive management would be implemented in order to ensure success. The following subsections identify triggers that would indicate the need to implement adaptive management measures and the measures that would be implemented accordingly.

Adaptive Management Triggers

- Desired Outcome: Increase percent cover of native riparian habitat.

  Triggers: If 50% cover of native riparian habitat is not achieved within 3 years, or 75% cover of native riparian habitat is not achieved within 5 years.

- Desired Outcome: Decrease percent cover of non-native invasive species that outcompete natives.

  Trigger: If non-native percent cover is greater than 20% during the monitoring period.

Adaptive Management Measures

If the triggers established above occur, the following measures would be implemented for riparian habitat in order to adaptively manage the site for success.

- Replanting may be needed if triggers for native vegetative cover are being met. Monitoring results should be used to assess the underlying cause of inadequate cover, which may require that additional adaptive management actions be implemented to support successful replanting. Adaptive management actions could include targeted revegetation, such as replanting varieties of species that are exhibiting the greatest growth and survival, or planting at elevations that are exhibiting the greatest growth and survival.

- Nonnative species management may be needed if monitoring results show that the triggers for nonnative species present are met, or if nonnative species are impacting the survival of native species. Adaptive management measures may include adjustments to nonnative control methods, such as plant removal, grading of site to remove nonnative roots, or mowing and selective removal of non-native species at optimal times for native growth.

- Irrigation and/or supplemental water may be needed if vegetation is not meeting success criteria, or if species are exhibiting signs of water stress. Assessment of monitoring results may show that drought conditions are causing poor establishment or die off of planted vegetation. Adaptive management actions would include supplemental water to support achievement of percent cover criteria and structural diversity.

- Plant protection may be needed if triggers for native vegetative cover are being met. If monitoring results show that plantings are failing due to predation or trampling, then adaptive management actions would include plant cages or protective fencing that could be installed to protect plantings.

3.3 Aquatic Planting

3.3.1 Objectives and Implementation Strategy

Bulrush (*Schoenoplectus* spp.) would be planted on the sand mounds following their establishment period. Cattail (*Typha* spp.) is expected to colonize the mounds through natural recruitment. Other aquatic species to be planted are rushes, sedges and spike rushes. Aquatic vegetation would be propagated from local sourced and planted as plugs into the sand mounds. Plantings would occur each year for about 10 years.

The primary objectives for installing aquatic plantings is to aid with native marsh vegetation recruitment, to create more stable and resilient sand mounds, and to promote sustainability through enhanced sediment accretion. Vegetated intertidal marsh habitat would improve water quality, provide more beneficial restored shallow water habitat for juvenile and adult fish species, and would provide nesting habitat for shore birds. In addition to providing refugia for native species, the aquatic vegetation would provide a valuable food source for both native fish and native avian species.

3.3.2 Success Criteria

Monitoring of aquatic vegetation would focus on: (1) the percent cover of native aquatic plant species; (2) presence of nutrient sources in fine sediment layers; and (3) water quality levels throughout the restoration area. The aquatic vegetation would be considered successful if the following criteria are met: (1) 70% average vegetative cover on sand mound plantable acreage; (2) less than 10% average vegetative cover on sand mount plantable acreage is non-native invasive vegetation; and (3) water quality monitoring levels remain within 90% of reference site levels.

3.3.3 Monitoring Strategy

The following monitoring procedures will provide the information necessary to evaluate the success of aquatic vegetation. Vegetation sampling will occur annually for the duration of the monitoring period. Sampling will occur during spring months, at the peak of growing season, and will consist of either boat or canoe-based visual surveys or snorkel surveys. In addition, monitoring would include a one day drone flyover of the habitat and a biologist assessment of the resulting video. Monitoring will measure percent cover of native plant species, and will also document if there is presence of non-native aquatic vegetation. Photograph stations are also important for documenting vegetation conditions. All photograph stations will be documented via Global Positioning System (GPS) coordinates to maintain consistency throughout the establishment and monitoring periods.

General observations, such as fitness and health of plantings, native plant species recruitment, and signs of drought stress would be noted during the surveys. Additionally, potential soil erosion, flood damage, vandalism and intrusion, and pest problems would be qualitatively identified. A general inventory of any wildlife species observed and detected using the restoration site would be documented. Nesting sites and other signs of wildlife use of the newly created habitat would be recorded.

Water quality monitoring could also provide insights into the success of the aquatic vegetation. Water quality monitoring was described above in Section 3.1.3. No additional monitoring would occur beyond what was proposed for the sand mounds above; however, the results of that monitoring could be used to assess the need for adaptive management measures to ensure aquatic vegetation success as well.

Monitoring reports documenting the restoration effort would be prepared following the first monitoring period and would continue annually until the site has met the success criteria. Monitoring reports would include photos, the timing of the completion of the restoration, what materials were used in the restoration, and plantings (if specified). Monitoring reports would also document the results of the percent cover measurements, the proportional abundance of different habitat types, and the estimated natural recruitment versus planted habitats. Monitoring reports would also include recommendations for additional adaptive management measures, if necessary. Following the monitoring period, any subsequent monitoring activities would be the responsibility of the non-Federal sponsor.

3.3.4 Adaptive Management Strategy

If the habitat is not meeting the success criteria established above, then adaptive management would be implemented in order to ensure success. The following subsections identify triggers that would indicate the need to implement adaptive management measures and the measures that would be implemented accordingly.

Adaptive Management Triggers

- Desired Outcome: Increase percent cover of native aquatic vegetation.

  Triggers: If 50% cover of native aquatic habitat is not achieved within 3 years, or 60% cover of native aquatic habitat is not achieved within 5 years.

- Desired Outcome: Ensure that water quality remains stable or improved from reference site conditions.

  Trigger: Water quality parameters are lower than 90% of reference site.

- Desired Outcome: Decrease percent cover of non-native invasive species that outcompete natives.

  Trigger: If non-native percent cover is greater than 20% during the monitoring period.

Adaptive Management Measures

If the triggers established above occur, the following measures would be implemented for aquatic vegetation in order to adaptively manage the site for success.

- Replanting may be needed if triggers for vegetative cover are being met. Monitoring results should be used to assess the underlying cause of inadequate cover, which may require that additional adaptive management actions be implemented to support successful replanting. Adaptive management actions could include targeted revegetation, such as replanting varieties of species that are exhibiting the greatest growth and survival, or planting at elevations that are exhibiting the greatest growth and survival.

- Nonnative species management may be needed if monitoring results show that the triggers for nonnative species present are met, or if nonnative species are impacting the survival of native species. Adaptive management measures may include adjustments to nonnative control methods.

- Additional adaptive management that could be applied to ensure success for aquatic vegetation includes the water quality adaptive management measures listed in Section 3.1.4 above. If water quality monitoring is meeting the triggers above, and aquatic vegetative cover is also not meeting success criteria, there could be the need for adjustments to the sand mound formations in order to ensure both water quality success and vegetative cover success.

3.4 Monitoring and Adaptive Management Costs

Table 4. Monitoring Costs for the Delta Study Recommended Plan

Monitoring	Assumed Tasks for Monitoring	Frequency	Cost Assumptions	Total Cost
Sand Mounds/ Dredged Material Placement	Survey crew assessing the site by boat and measuring depths and elevation levels using a depth finder and GPS unit.	Annually from construction year 2 until 1 year post-construction (10 years total). Additional frequencies may need to occur following high water/flood events.	$9,000 additional cost for labor, boat time, and lodging per year.	$90,000
*Water Quality Monitoring – Up front**	Acquisition, assembly, installation by ERDC	Year 1 Only	$205,000 for equipment and setup by ERDC	$205,000
*Water Quality Monitoring – Annually**	Remote sondes with transmitters would take hourly readings of water quality parameters such as temperature, dissolved oxygen, and conductivity.	Two people would service every 6 weeks for 15 years	Annual costs include $60,700 service cost and $24,000 for data housing and analysis by ERDC. Total annual cost is $84,700.	$1,270,500
Riparian Vegetation Monitoring	Assume monitoring for percent cover of natives and non-natives. Assume monitoring would be done concurrently with other monitoring actions.	Annually for 15 years	Since monitoring would occur concurrently with other monitoring actions, no additional costs are required.	$0
Aquatic Vegetation Monitoring	Visual surveys on a boat during other monitoring activities.	Annually for 15 years	$18,307 annual cost	$274,605

	1-day drone flyover of habitat. Assume monitoring for percent cover of natives and non-natives, vegetation mapping, inventories of general wildlife, and observations of damage to habitat would be recorded.			
TOTAL MONITORING				$1,840,105

*Water Quality Monitoring associated with both Sand Mound Creation and Aquatic Vegetation Monitoring.

Table 5. Adaptive Management Costs for the Delta Study Recommended Plan

Restoration Feature	Adaptive Management Measures	Assumed Tasks for Adaptive Management	Cost Assumptions	Total Cost for Monitoring Period
Sand Mound/ Dredged Material Placement Measures	Water Quality Assessment	Project team interprets data and develops one of the below responses.	5 scientists at $1,200 per day, 2 events	$24,000
	Hay bale placement	Install hay bales, truck to site, load onto barge/boat, place	**1 time cost**	**$44,201**
	Reshaping of channels	Barge with pump to hydraulically shift sand.	**2 time cost ($35,765 per event)**	**$71,530**
	Increase elevation of mounds	Add material next dredging season.	**No additional cost beyond annual construction cost.**	**$0**
	Abandonment	Add material next dredging season	**No additional cost beyond annual construction cost.**	**$0**
	Water Quality Assessment – continued degradation	Expert elicitation to assess water quality anomalies.	**1 time cost $35,765**	**$35,765**
Riparian Vegetation Measures	Detailed survey for invasive plants	2 biologists	2 time cost of $9,000	$18,000
	Non-native plant removal	Regimes of cutting and spraying. May include some replanting to out-compete non-native vegetation.	Assume 9 acres of eradication per event & 2 events over the monitoring period. $53,833 per event.	$107,666
Aquatic Planting	Install additional aquatic vegetation	Assume 1 attempt to replant original species	1 time cost	$129,945
	Develop new planting regime	Use of different species in subsequent years	No additional cost beyond annual construction estimates	$0
TOTAL ADAPTIVE MANAGEMENT			**$ 431,107**	
TOTAL MONITORING AND ADAPTIVE MANAGEMENT			**$ 2,271,212**	