Attachment C: Preliminary Draft Monitoring and Adaptive Management Plan (MAMP) for the Cullinan Ranch Unit of San Pablo Bay National Wildlife Refuge. [Do to time constraints, some links in this attachment have not been updated yet but will be in the Final Order.]

MONITORING

This document details the monitoring plan for construction and habitat evolution at the Cullinan Ranch Unit (Cullinan) of San Pablo Bay National Wildlife Refuge. The monitoring plan includes both biotic and abiotic parameters that would be monitored, performance standards, habitat targets, protocols, and sampling frequencies for the entire unit. This plan also identifies potential adaptive management triggers. The monitoring methods, schedule, and reporting system are also described in the Cullinan Ranch Mitigation, Monitoring, and Reporting Plan Table (Table 1), which summarizes parameters to be monitored, performance objectives, protocols, and monitoring frequency.

1.0 Background

A monitoring plan was developed in 2006 to track the progress of the Napa Plant Site project with input from the Water Board staff and the Bay Area Monitoring Review Team (MRT), which met on May 15, 2006 to discuss monitoring of the Napa Plant Site project. Because Cullinan Ranch is located adjacent to the Napa Sonoma Marshes and is a similar tidal restoration project we will use the same monitoring approach developed for the Napa Sonoma Marshes and approved by the Water Board and the MRT, with minor changes, as appropriate, to adapt the plan for the Cullinan Ranch site. In addition, we have reviewed and incorporated adaptive elements of the South Bay Salt Pond monitoring plan where feasible (e.g., see Table 2, Adaptive Management Strategy).

1.1 Monitoring Components and Performance Objectives

Over a 15-year period, chemical, physical, and biological project components will be monitored for the restoration project. In addition, aerial or satellite photos will continue to track tidal marsh development every 5-10 years until the final objective of tidal marsh is achieved (defined here as having 75% cover of native tidal marsh plant species).

1.2 Chronology

Project construction will be completed when tidal action has been restored. After construction has been completed the San Pablo Bay NWR will submit a construction completion report to the Water Board, Corps, and BCDC within 45 days and an as-built report within 45- 90 days. Upon approval of these reports (or after 45 days from submission), the monitoring period will commence.

2.0 Monitoring Methods and Schedule

This section presents monitoring protocols for water quality, biota, and geomorphic evolution. The monitoring schedule is also discussed and summarized in Table 1.

2.1 Water Quality

General Water Quality Parameters: Water quality monitoring is specifically associated with project construction to assess the effects of breaching on the receiving water quality. General water quality parameters to be monitored include salinity, temperature, pH, dissolved oxygen (DO), and turbidity. Water quality parameters will be monitored *in situ* by collecting a grab sample and using a multi-parameter probe and flow cell (e.g., YSI 6820 or equivalent). Figure C-1 shows water quality sampling locations. Monitoring stations will be associated with the breach on South Slough and one of the three breaches on Dutchman Slough and receiving water upstream and downstream of the breaches (i.e., South Slough and Dutchman's Slough). In addition there will be a monitoring station inside one of the Dutchman Slough breaches. The sampling station locations will allow assessment of interior water quality, site effluent and receiving water quality, and provide the means for estimation of the attenuation of any water quality conditions that may exist (e.g., low DO concentrations).

Water quality data will be collected at one foot below the surface during an ebbing tide. Data will be collected at the following frequency:

- within 3 days prior to breaching of the pond levees;
- once during the first 24 hours after breaching, and again within 5 days after the breaching;
- weekly for the first month after breaching; and
- monthly until water quality performance objectives have been met for three consecutive months.

Water quality monitoring data will be evaluated for trends and compared to the performance objectives established for each parameter.

Annual Mercury Monitoring: Water, sediment, and/or biosentinels can be monitored for mercury. If biosentinels are chosen they should ideally (but not necessarily) follow regional protocols used for similar sites such as Mississippi silversides sampled at the Napa Plant Site. In addition, biosentinels should cover all existing and target habitats (e.g., mudflats, channels, vegetated tidal marsh plains, etc.) and each habitat should have between 3-5 samples collected from it). Appropriate species and habitats include: Mississippi silversides for the subtidal areas; mudsuckers for intertidal mudflats and channels; and song sparrows for the tidal marsh plain. Other species can be selected if they are common, reside primarily in the habitat, and are not a threatened population. In addition, a different monitoring plan can be proposed and presented to the Water Board and the Technical Advisory Team for this project. The Water Board must approve changes.

2.2 Biota

This section discusses biological monitoring, including avian monitoring, fish as used for biosentinel mercury monitoring, small mammals, and vegetation.

Birds

Avian surveys will be conducted four times a year in years 1-3 (focused on migratory and winter periods); and thereafter four times a year every 5 years (i.e., Years 8 and 13) or until vegetation cover reaches 75 percent and the predominant bird use shifts from shorebirds and waterfowl to resident marsh species (e.g., songbirds, rails), whichever is sooner. Surveys will occur during migratory periods and encompass high and low tides. Wetland bird surveys will be conducted using the Wetland Regional Monitoring Program protocols (2002; http://www.wrmp.org/protocols.html) or other appropriate protocol. The Refuge will monitor California clapper rails when appropriate quantity and quality of habitat has developed (e.g., 300 acres of contiguous vegetated marsh).

Data from United States Geological Survey (USGS) bird surveys conducted at the Napa Sonoma Marshes project site between April 2003 and March 2006 will be used as a baseline for comparison of data collected in the post-project monitoring period. Other comparison data may include the estuary-wide shorebird surveys coordinated by Point Reyes Bird Observatory and the winter waterfowl surveys conducted by the United States Fish and Wildlife Service (USFWS). Data analysis will include an evaluation of species composition, abundance and trends in bird use relative to San Pablo Bay and the larger San Francisco Estuary. The Refuge will coordinate with the Napa Solano Audubon Society to add a Christmas Bird Count Station at the Cullinan Ranch Site.

Fish

The Refuge will coordinate with regional programs to conduct fish monitoring at the Cullinan Ranch site. Monitoring would occur once per year for the first three years; and thereafter one survey a year every 5 years or until the site supports fish communities similar to reference estuarine tidal marsh sites.

Small mammals

Tidal marsh habitats can support populations of special-status small mammals, including salt marsh harvest mouse (*Reithrodontomys raviventris*) (SMHM) and Suisun ornate shrew (*Sorex ornatus sinuosus*). It is the Refuge's responsibility as a federal agency to make efforts toward the conservation and recovery of these species. The Refuge will monitor or document the presence or absence of federally listed small mammals at Cullinan in accordance with the established recovery programs. Surveys for small mammals will be conducted 1 year prior to construction. If suitable habitat is present and vegetation cover averages at least 75%, post-construction surveys will begin in year 3 following construction, or as soon thereafter as suitable habitat is present, and will continue once every year until SMHM occupy available habitat for a period of at least 3 years.

Vegetation

Vegetation colonization in wetland areas will be monitored using aerial photography supported by ground-truthing. Aerial images will be interpreted with a Geographic Information System (GIS) to estimate percent cover in the wetland areas. Ground-truthing will be performed to

verify vegetation signatures on the aerial photos, and to make qualitative assessments of species richness and community composition.

A minimum of 30 acres of habitat suitable for colonization by native marsh vegetation will be created along South and Dutchman Sloughs and along the buttress levee. Up to an additional 50 acres will be created next to Guadalcanal Village if funding and surface quality sediments are available. Vegetation colonization in these areas is expected to be fairly rapid, beginning within one year of project completion, and achieving 80% native tidal marsh vegetation cover within 3 to 10 years. The remainder of the site is expected to take approximately 60 years to meet the 75% cover success criterion for native tidal marsh vegetation.

Vegetation assessment will analyze species cover, richness, and composition. Vegetation assessment will begin when aerial imagery or ground-based observations suggest that tidal wetland-associated plant cover is approximately 20 percent. Prior to reaching the 20% level, the dominant pioneer species colonizing the marsh plain will be recorded.

The Refuge has an invasive plant management program to prevent and control non-native invasive plant species, including those listed under Tier I (and to a lesser extent Tier II) of the Water Board's "Invasive Non-Native Plant Species to Avoid in Wetland Projects in the San Francisco Bay Region"[1], that threaten sensitive native tidal marsh communities. The Refuge will review this list and determine which species will be feasible to keep off the wetland restoration site, and which will not. Invasive cordgrass species (e.g., *S. alterniflora, S. densiflora*) and *Lepidium latifolium* (perennial pepperweed) are currently high priority species for control or eradication on Refuge lands. The Refuge coordinates with the Invasive Spartina Project to control invasive *Spartina* species in San Pablo Bay.

2.3 Geomorphic Evolution

Protocols developed by the San Francisco Estuary Institute for mapping vegetation using aerial and satellite photos will be reviewed and followed if feasible[2]. The practicality of providing some form of habitat mapping including vegetation types and channel evolution is being investigated using aerial or satellite photos collected every 1, 3, or 5 years; easily accessible satellite photos such as Google Maps can be used, if they provide sufficient detail to assess the development of habitats including channels. A final plan will be submitted to and approved by the Water Board's Executive Officer.

2.3.1 Tidal Channel Evolution

Evolution of tidal channels will be evaluated using aerial imagery. The aerial images will be captured in the first year before construction is completed (the baseline), followed by the first year after construction is completed, and subsequently every five years during a spring low tide

[1] http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stream_and_wetland_protection.shtml under "Fact Sheet for Wetland Projects, Appendix I- Invasive Non-native Plants").

[2] In addition to protocols for tidal marsh vegetation mapping from aerial and satellite imagery, this site also has protocols for monitoring tidal marsh plants and animals, as well as sedimentation rates. (see www.wrmp.org/documents.html; under "Protocols".

to increase visibility of channel network development, until the performance criteria are met or the Technical Advisory Team determines that the tidal channel networks had developed sufficiently. Aerial images will be interpreted with GIS to calculate: 1) overall channel density in the drainage basin associated with each breach; 2) channel width at each breach and at locations along the alignment of the restored historic channels. Density will be calculated as square feet of channel per square feet of marsh plain.

2.3.2 Sedimentation

Sedimentation in restored tidal areas will be monitored using sedimentation plates, pins, erosion tables or LiDAR. If sedimentation plates are used, each plate will be constructed of a square sheet of non-corrosive material. Sedimentation plates will be set flush with the marsh surface prior to restoration of tidal action. A rod will be placed through the center to anchor the plate and facilitate relocation for sampling purposes. Sediment accumulation on the plates will be measured in years 1, 5, 10, and 15. A total of 6 plates will be placed on the site before tidal action is restored, but only 3 of those need to be measured regularly; the remaining 3 will be kept in reserve for measuring, in case the predicted deposition fails to produce elevations at which vegetation develops. Initial elevations will be recorded for all plates.

3.0 Reports

The agencies will be notified by email when construction starts and ends, and when levee breaches occur. A start-up (or construction completion) report will be submitted within 45 days after construction stops. As-built plans will be submitted to the Corps, BCDC, and the Water Board within 45-90 days of the completion of construction. The plans will note changes from the final bid set of plans and will be accompanied by notes from the construction manager and monitor.

After construction is completed, biennial technical monitoring reports (every two years) will alternate with less technical memos to assess project success. The biennial technical reports will describe the data collected pursuant to the approved restoration plan and will be submitted in years 2, 4, 6, 8, 10, 12, and 14. Beginning on March 31st after construction is completed for 15 years post-construction. If feasible, the alternating biennial memos will be submitted by March 31st in the alternate years beginning with year 1 and ending with year 13. A final report will be due on March 31st of year 15. The memos and reports should, at a minimum, state whether review of easily accessible satellite photos looked at annually show any large-scale, unplanned, potentially troublesome occurrences such as excessive erosion, sedimentation, or invasions by unwanted plant species. Satellite photos are expected to be free from the website and no quantitative GIS analysis is expected for the annual review.

All reports will evaluate and discuss biotic and abiotic elements of the monitoring program. The monitoring reports will include the Corps, BCDC, and Water Board permit numbers, a list of the names of the persons who conducted the monitoring and prepared the report, a brief description of the restoration project, dates monitoring was conducted, photographs and figures identifying monitoring station locations and photo points. The biennial memos can be brief summaries of the previous year's data and can address problems and make recommendations for the project. Biennial post-construction technical monitoring reports will include monitoring results, analysis of quantitative monitoring data, an evaluation of performance objectives, suggested corrective

actions, if appropriate, suggested changes in the monitoring program, and recommendations to guide this and future restoration projects. Results of the water quality sampling will be presented in the 1st year. Qualitative data and a qualitative review of sedimentation, tidal channel evolution, and vegetation colonization will be included in the Year 2 and Year 4 reports. Trend analysis of sedimentation, tidal channel evolution, and vegetation colonization will begin in Year 6, or as soon thereafter as sufficient data are available. Monitoring reports will include details of any adaptive management actions that have been implemented in the preceding year, if applicable. Monitoring reports will be submitted to the Corps, the Water Board, and BCDC.

4.0 Notification of Completion

The Refuge will notify the Corps, BCDC, and the Water Board at the end of the 15-year monitoring period, or when the performance objectives have been met. A site visit to confirm completion status will be scheduled. The hypothesized target of 75% cover of native tidal marsh plant species may not occur for 60 years or longer. If the site does not develop as expected after15 years of monitoring, then the Refuge will attempt to analyze habitat development and report to the agencies every 5-10 years on the development of the site toward meeting that target. If monitoring commitments detailed above have been met and the site has not reached its expected long-term habitat goals, the Refuge will assess and possibly implement appropriate methods to meet existing goals. The Refuge may also need to revise habitat goals and associated project assessments to reflect changes occurring throughout the Estuary (e.g., declining sediment inputs, sea level rise, evolution of surrounding tidelands) that could limit the ability of the Project to evolve as originally predicted. The determination of whether to implement additional measures to meet existing goals, or to revise habitat goals to reflect regional changes in the estuary will be made in consultation with the technical advisory committee for this project and the restoration community at a forum such as the Napa Sonoma Marshes Restoration Group or the San Francisco Bay Joint Venture which includes scientists, practitioners, and regulators that are directly involved in tidal marsh restoration and monitoring.

5.0 Contingency Measures

Corrective actions, if necessary, will be suggested in biennial monitoring reports for performance objectives that are not being met. The responsible party for implementing and monitoring required contingency measures is the San Pablo Bay NWR, represented by:

Donald Brubaker, Refuge Manager
San Pablo Bay NWR
7715 Lakeville Highway
Petaluma, CA 94954
christy_smith@fws.gov

6.0 Maintenance

The proposed project design minimizes operations and maintenance requirements, particularly because only two water control structures are included. Tidal restoration is self-sustaining and evolves to a dynamic equilibrium state without intervention. The project would require operation and/or maintenance of the following:

- Two water control structures on Pond 1 levee
- Buttress levee – weed control and mowing
- Public access features including the kayak launch, fishing/wildlife observation pier, kiosk and interpretive signs
- Invasive plant control and native plant restoration of the marsh-upland ecotone

The two water control structures and the buttress levee will be inspected for erosion, settlement, excessive burrowing animal activity, and/or presence of deep-rooted woody plants. Routine mowing and maintenance should forestall these problems. Trash receptacles would also require regular maintenance.

7.0 Adaptive Management

The ability to react to changing circumstances is the basis for adaptive management. The adaptive management premise is to address issues as they arise; developing solutions based on contemporary circumstances and available resources. Issues that may require adaptive management include mosquito abatement, invasive species, erosion, flooding, and others. The Refuge will develop solutions to management needs as they arise. The Refuge has developed a set of restoration targets and triggers for potential management action (Table 2). An evaluation of tidal marsh evolution relative to stated projects targets and triggers will be presented in the biennial monitoring reports.

Mosquito Abatement

As vegetation becomes established on the site potential mosquito habitat may increase. During the time that the site is at or below mean high water it is predicted to drain well, even as vegetation begins to establish. The mature marsh plain has potential to include deep water pools connected by channels. Shrink/swell cracks that develop on mudflats or in vegetation could serve as mosquito breeding habitat. The project would lower the levees adjacent to the Dutchman and South Sloughs to mean higher high water level so that inundation will occur daily. These levees will also be breached at or below the thalwag of the connecting slough in numerous locations to facilitate adequate drainage. Most of Cullinan Ranch will be a deep body of water at high tide each day and will not support mosquito populations for at least 50 years.

Table 1. Cullinan Ranch Monitoring and Reporting Plan: a summary of 15-Year monitoring program parameters, performance standards, targets, protocols, and frequencies. The 15-year monitoring period will begin after construction is completed. In addition to the monitoring elements below, the use of best management practices and site monitoring to ensure that pollutants are not discharged to the Bay or Dutchman or South Sloughs will also be conducted during construction periods. The US FWS can propose changes to the monitoring program depending on its feasibility and cost over the anticipated 60-year evolution of the site.

Parameter	Performance Standard	Target*	Protocol	Frequency
Field Photo Monitoring	None, purpose is documentation of tidal marsh evolution	Establishment of native tidal marsh plant communities	Establish photo monitoring points for ground images	• 1 yr pre-construction • Post-construction yrs 1, 5, 10, 15
Aerial or Satellite Photo Monitoring	Purpose is documentation of tidal marsh evolution and meeting vegetation performance standards (see below)	Establishment of native tidal marsh plant communities Mudflat and channel development	Obtain aerial images from sources explained in SFEI's** vegetation mapping protocol for aerial/satellite photos, or readily-available, free public source such as Google Maps®	If feasible, review annually through year 15 only for large-scale, unplanned changes to the site (no technical or quantitative review is required for the annual satellite or aerial image review.). If vegetation performance criteria not met after 15 years, then consult Technical Advisory Committee for this project. Thereafter every 5 years until vegetation performance standards are met (if feasible)
Dissolved oxygen (DO)	Outflow of water from the site will not decrease DO concentrations in the receiving waters during any tide cycle to a concentration lower than 5.0 mg/L (Basin Plan water quality objective downstream of Carquinez Bridge) or below the ambient concentration if the ambient concentration is less than 5.0 mg/L. The median DO concentration for any three consecutive months shall not be less than 80 percent of the DO content at saturation.	Maintain water quality in Dutchman and South Sloughs	Grab water sample/data collection using a multi-parameter probe and flow cell (e.g. YSI 6820 or equivalent) at monitoring stations associated with the South Slough breach and one of the three Dutchman Slough breaches, as shown in Figure 1. If feasible, data will be collected more than one foot below the surface during ebbing tide and more than one foot above the bottom.	• 3 days prior to breaching the levees • During the first 24 hours after breaching • 5 days post-breach • Weekly for the first month after breaching • Monthly until water quality performance objectives have been met for three consecutive months.

Salinity	Instantaneous maximum: < 100 ppt Monthly Average < 50 ppt	Maintain water quality in Dutchman and South Sloughs	Same protocol as for dissolved oxygen	See dissolved oxygen
pH	Outflow of water from the site will not cause changes greater than 0.5 units of pH in the receiving waters during any tide cycle. The pH shall not be depressed below 6.5 nor raised above 8.5, or below ambient pH if the ambient pH is less than 6.5, or above the ambient pH if the ambient pH is greater than 8.5	Maintain water quality in Dutchman and South Sloughs	Same protocol as for dissolved oxygen	See dissolved oxygen
Temperature	Outflow of water from the site will not increase temperature by more than 5°F (2.8°C) in the receiving waters during any tide cycle in the wet season, and 10°F in the dry season	Maintain water quality in Dutchman and South Sloughs	Same protocol as for dissolved oxygen	See dissolved oxygen
Turbidity	Outflow of water from the site will not increase turbidity in the receiving waters during any tide cycle by more than 5 NTU if the ambient turbidity is less than 50 NTU, or by more than 10% if the ambient turbidity is greater than 50 NTU (or as close to these targets as practicable given the likelihood of turbidity immediately post-breach and following heavy rainfall events)	Maintain water quality in Dutchman and South Sloughs	Same protocol as for dissolved oxygen	See dissolved oxygen
Methyl mercury	Mercury concentrations in water, sediment, and/or biota tissue samples over time are less than concentrations in samples collected from comparable habitats in the San Pablo Bay watershed. Methyl-mercury can be sampled in sediment or water but biosentinels are preferred.	Maintain water quality in Dutchman and South Sloughs	Protocol acceptable to RWQCB, e.g. regional biosentinel fish tissue monitoring such as the one developed by UC Davis	1 sample for each habitat type (3-5 samples), annually, if feasible; coordinated with other biosentinel fish or other biosentinel monitoring in the region (e.g., Napa Marsh, Napa Plant Site, South Bay Salt Pond, Bair Island, or Sears Point) to result in meaningful data

Birds	None, purpose is documentation of tidal marsh evolution	Bird use will increase, particularly among diving and dabbling ducks over the shorter term; and among shorebirds, songbirds, and rails over the longer term	Area bird surveys using WRMP wetland bird protocols, regional shorebird surveys (PRBO), winter waterfowl surveys (USFWS)	Years 1-3: four times a year Thereafter four times a year every 5 years (i.e., Years 8 and 13) or until vegetation cover reaches 75%, whichever is sooner
Vegetation	30-80 acres of habitat at marsh plain elevation with 80% cover within 3-10 years	Short-term: minimum of 30 acres of 75% native tidal marsh plant community cover Long-term: native tidal marsh plant communities occupy 75% of the project area (approx. 1,100 ac)	On-going observations (as part of routine site maintenance and control) to detect non-native invasive species; to the extent feasible control highly invasive species on the RWQCB's Tier 1 list of species to keep out of wetland sites ***; Aerial photography or Google Maps® images and GIS to define extent of vegetation communities and total percent cover; ground-truth to identify dominant species, define communities, assess species richness & composition when vegetation cover reaches 20%; map vegetation when cover exceeds 20%	Biennial or annual observations (not technical surveys) of colonizing species to locate and eradicate invasive non-native species. Priority species to eradicate is up to FWS staff and is likely to include *Spartina alterniflora, S.densiflora, Lepedium latifolium* and species designated as high priority by Bay Area Early Detection Network. If feasible, mapping and reporting every 2 years after 20% plant cover is attained. Ground observations in conjunction with aerial imagery analysis once 20% plant cover is attained and thereafter every 10 years until plant communities occupy 75% of the project area
Salt Marsh Harvest Mice	None, purpose is documentation of tidal marsh evolution	Site will support and provide habitat for small mammals, including salt marsh harvest mice	Monitor or document the presence or absence of federally listed salt marsh harvest mouse at the project site in accordance with the established USFWS protocols and recovery plan. Salt marsh harvest mouse surveys will be completed 1 yr pre-construction; yr 3 post-construction, or as soon thereafter as vegetation cover reaches 75%; annually thereafter until 3 consecutive yrs of SMHM presence.	As determined by USFWS, see also Table 2.

California Clapper Rail and other Rail Species	None, purpose is documentation of tidal marsh evolution	Site will support rail species, including CA clapper rail and CA black rail, where adjacent source populations exist and adequate amounts of high quality habitat is present	Monitor or document the presence or absence of federally listed California clapper rails at the project site in accordance with the established USFWS protocols and recovery plan. Breeding season surveys will commence once 300 ac of contiguous habitat has developed	As determined by USFWS, see also Table 2.
Estuarine Fish	None, purpose is documentation of tidal marsh evolution			As determined by USFWS, see also Table 2
Tidal channel evolution	None, purpose is documentation of tidal marsh evolution	Density and size of tidal channels will increase throughout the duration of the monitoring period	Aerial photograph; SFEI's recommended protocol**; or Google Maps® image interpreted with GIS to calculate overall channel density in the drainage basin associated with each breach (sq. ft. channel per sq. ft. of marsh plain). Top width of each breach measured in GIS from aerial images	Years 2, 5, 10, and 15
Sedimentation	None, purpose is documentation of tidal marsh evolution	The site will fill in with enough sediment within 60 years to support native tidal marsh vegetation through most of the site; some deeper areas may persist longer	Deposition resulting in marsh plain accretion to the MHW elevation will be mapped as vegetation germinates and colonizes the site. Sediment plates, pins, erosion tables or LiDAR will be used to monitor deposition. If sediment plates or pins are used, 6 monitoring locations will be established in appropriate areas throughout the site, and the 3 in the lowest areas will be measured. If vegetation establishment or sedimentation rates are below expectations, the remaining 3 locations will be monitored to determine sedimentation rates in those areas	Years 2, 5, 10, and 15

*No penalties for failure to achieve the targets in this column are expected since that would discourage important restoration projects. However, failure to achieve targets should prompt the USFWS to investigate the causes for failure, recommend management measures to protect beneficial uses, and report those recommendations to the resource agencies and the public.

**San Francisco Estuary Institute: http://www..wrmp.org/documents.html; under Protocols, "Tidal Marsh Vegetation Mapping"

http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stream_and_wetland_protection.shtml under “Fact Sheet for Wetland Projects” (Appendix 1: Invasive Non-Native Plants).

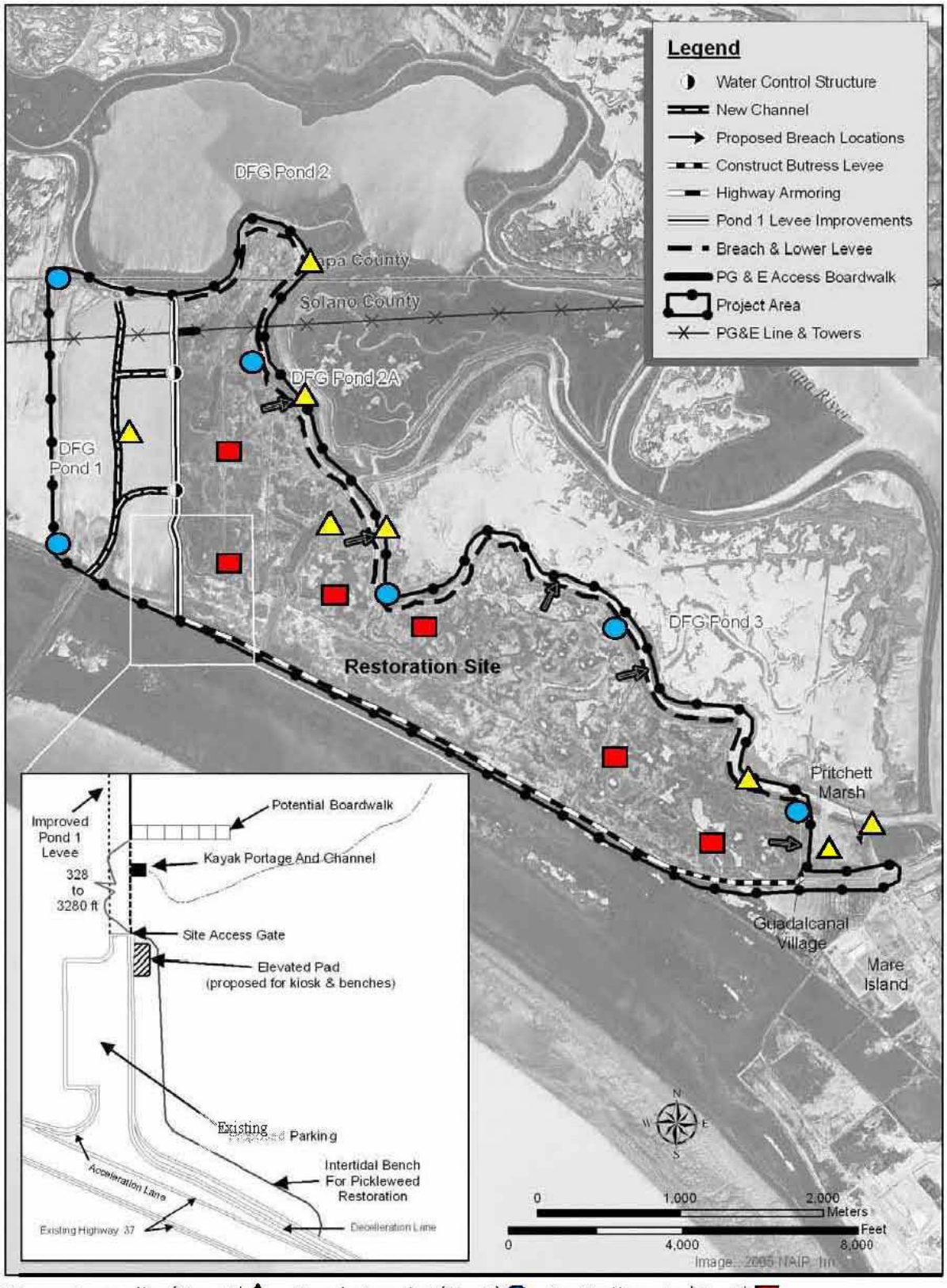
Table 2. Cullinan Ranch Tidal Marsh Restoration: Adaptive Management Strategy.

Category	Project Purpose[1, 2]	Restoration Target	Expected Timeframe	Monitoring Parameters and Methods	Management Threshold for Action	Potential Management Action
Sediments	Sediment accreting at rates along a trajectory sufficient to support tidal marsh plant colonization	Project elevations capable of supporting tidal marsh vegetation over 75% of the project area (approx. 1,100 ac)	60 years[3]	Sedimentation rates, total accumulation, or bathymetry using sedimentation plates, pins, erosion tables or LiDAR; assessments at 2, 5, 10, and 15 yrs and 10-yr intervals thereafter	Projections based on data gathered in the 1st 15 years suggest elevations required for vegetation colonization are not likely to be achieved	Re-evaluate projections/timelines and likelihood of achieving tidal marsh elevation and associated habitat development relative to regional changes in sediment dynamics and sea level rise
Tidal Plant Community Development	• Restore habitat for the recovery of federally- and state-listed special status species • Provide habitat for a broad range of marsh-dependent birds, mammals, fish and other aquatic organisms, and migratory shorebirds and waterfowl	• Development of tidal marsh plant communities (e.g., channel edge, low/middle/upper marsh, pan, marsh-upland ecotone): evolution of native plant composition and structure similar to successful tidal marsh restoration projects of the North Bay or reference tidal marsh sites once appropriate elevations have been achieved • Short-term: 30-80 acres of habitat at marsh plain elevation with 80% cover • Long-term: achieve 75% cover of native tidal marsh plant communities (approx. 1,100 ac)	• 3-10 years (30-80 acres) • 60 years[3]: 75% cover of native tidal marsh plant communities	• Qualitative assessment of pioneering species and dominance prior to attaining 20% cover of tidal marsh plants (biennial for 15 years) • Acres of tidal marsh plant communities: aerial photo interpretation, ground-truthing, and GIS when vegetation cover is ≥ 20% (10-yr intervals) • Ground surveys (annual or biennial) for high priority[4] invasive plant species (e.g., *Spartina alterniflora*, *Lepidium latifolium*); priority species and timeframe for monitoring will be adapted through time as conditions change	• Invasive plant colonization and spread by high priority[4] invasive species • Lack of colonization by native halophytes once appropriate elevations have been reached	• Active revegetation from local plant sources • Increased invasive plant management

Salt Marsh Harvest Mice	Restore habitat for the recovery of federally- and state-listed special status species[1]	• Create 30 acres of new SMHM habitat at approximately MHHW in elevation • SMHM colonizes new SMHM habitat from surrounding source populations (e.g., Guadalcanal) • Acres of high quality SMHM habitat increase through time (see 'Tidal Plant Community Development')	3-10 years (30 ac) 10-60 years[3] (habitat acres increase relative to baseline)	• Acres and quality of SMHM habitat developed (See 'Tidal Marsh Plant Community Development' monitoring parameters and methods) • Assessment of SMHM habitat quality based on current literature • Small mammal surveys (Year 3 post-construction and annually until SMHM are present for 3 consecutive years)	• See triggers for 'Tidal Marsh Plant Community Development' • Lack of colonization by SMHM when appropriate habitat is present	• Active revegetation • Increased invasive plant management • Study of adjacent source populations and potential barriers to movement
California Clapper Rail	Restore habitat for the recovery of federally- and state-listed special status species[1]	• Acres of high quality CLRA habitat increases through time (see 'Tidal Plant Community Development') • Populations similar to reference tidal marsh sites of San Pablo Bay	10-60 years[3] (habitat acres increase relative to baseline)	• Acres and quality of CLRA habitat developed (See 'Tidal Marsh Plant Community Development' monitoring parameters and methods) • Assessment of CLRA habitat quality based on current literature (e.g., Tidal marsh recovery plan) • Breeding season surveys when ≥ 300 ac of contiguous habitat develops (e.g., cordgrass)	• See triggers for Tidal Marsh Habitat development • Lack of colonization by CLRA when appropriate amount (e.g., >300 ac) and quality of habitat is present	• Active revegetation • Increased invasive plant management • Study of source populations and potential barriers to movement

Water Quality	Water quality parameters in receiving waters meet RWQCB performance standards[5] (e.g., DO, pH, turbidity, salinity, etc.).	• Maintain water quality in Dutchman and South Sloughs and the Napa River • Water quality parameters in receiving waters meet RWQCB performance standards (e.g., DO).	< 1year	• Grab water sample/data collection using a multi-parameter probe and flow cell at monitoring stations associated with the South Slough breach and one of the three Dutchman Slough breaches • 3 days prior to breaching, first 24 hours after breaching, 5 days post-breach, weekly for 1st month after breaching, monthly until RWQCB objectives have been met for three consecutive months	Water quality parameters in receiving waters do not meet RWQCB performance standards)	Consider active management (e.g., re-aeration mechanisms to improve DO; decrease residence times; increase flows from Pond 1).)
Mercury	Hg levels in sentinel species of the project area are less than or equal to what is found in existing habitats of San Pablo Bay . Methyl-mercury levels can be monitored in water and sediment instead of biosentinels.	Mercury concentrations over time less than or equal to concentrations in samples collected from comparable habitats of San Pablo Bay		Bio-sentinel fish tissue monitoring	Sentinel species show higher than ambient levels of Hg in the project area relative to comparable habitats of San Pablo Bay	Work collaboratively with regulators and restoration community to determine next steps

[1] U.S. Fish and Wildlife Service and California Department of Fish and Game. 2008. Draft Environmental Impact Statement/Environmental Impact Report Cullinan Ranch Restoration Project Solano and Napa Counties, California. Available at: http://www.fws.gov/cno/refuges/cullinan/1-TOC-ES.pdf. Accessed 21 May 2009.
[2]Ducks Unlimited and Gaia Consulting. 2009. Draft Biological Assessment Cullinan Ranch Restoration Project Napa and Solano Counties. Prepared for USFWS.
[3]Moffat &Nichol Engineers. 2004. Hydrodynamic modeling investigation Cullinan Ranch Restoration Project. In: USFWS and CDFG. 2008.
[4]priority of invasive species based on potential effects to tidal marsh plant community development, effects on endangered species habitat, invasiveness (e.g., rate of spread), high priority species identified by the Bay Area Early Detection Network, and Tier I (and to a lesser extent Tier II) of the Water Board's "Invasive Non-Native Plant Species to Avoid in Wetland Projects in the San Francisco Bay Region.



W = waterquality (N = 8) △ , P = photopoint (N = 6) ● , S = Sediments (N = 6) ■

Figure C-1. Sampling locations for Cullinan Ranch Restoration Project