BAIR ISLAND RESTORATION PROJECT
MONITORING PLAN

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1.0 INTRODUCTION

Bair Island is located adjacent to the San Francisco Bay in Redwood City, San Mateo County, California (Figure 1). Historically, Bair Island was part of a large complex of tidal marshes and mud flats within the drainage of Bay and Belmont Sloughs (PWA 2000). Bair Island was diked in the late 1800's and early 1900's for agricultural practices including cattle grazing. The island was converted to salt evaporation ponds by Leslie Salt Company starting in 1946, and remained in salt production until 1965. The lands were drained and eventually sold to a series of real estate development companies.

The California Department of Fish and Game (CDFG) and the Don Edwards San Francisco Bay National Wildlife Refuge (hereafter, "Refuge") both acquired portions of Bair Island over time. In 1997, the Peninsula Open Space Trust (POST) purchased the remaining portions of Bair Island and turned over their interest in the property to these agencies. The San Carlos Airport also retains a portion of Inner Bair Island as a safety zone. In addition, two easements exist on Bair Island for PG&E towers and transmission lines that run throughout the Bair Island complex and the South Bay System Authority (SBSA) force main that runs underneath most of the southern part of the levee on Inner Bair.

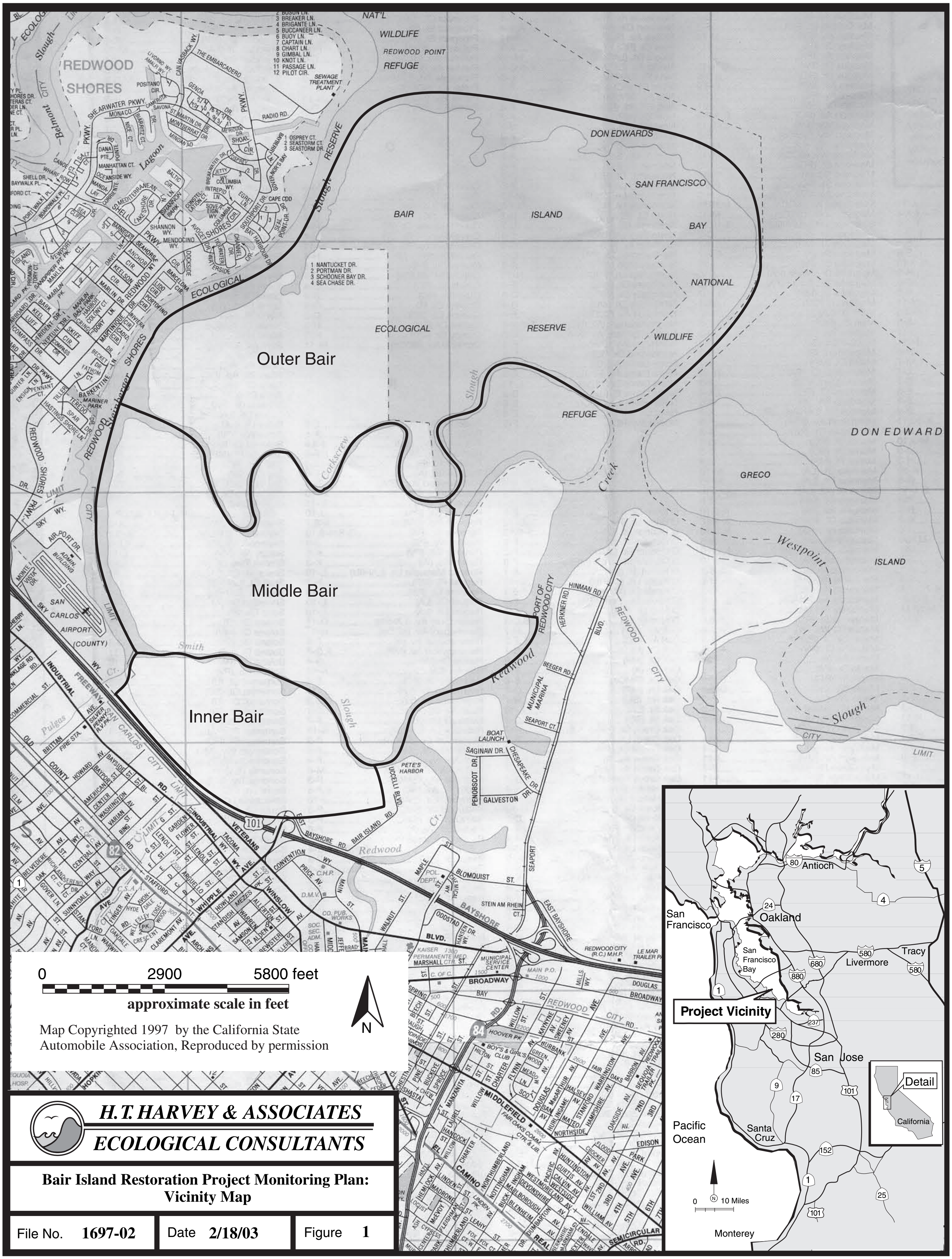
This site is a large, restorable complex of former salt evaporators, and has been a major priority for addition to the Refuge since the original boundaries were drawn. The restoration of tidal habitats at Bair Island is ecologically important to South San Francisco Bay. Following restoration, Bair Island will become an integral part of the extensive wetland complex within the Refuge and adjacent state and privately owned wetlands.

In addition to restoring 1400 acres of tidal wetlands to the much depleted South San Francisco Bay (SFB) tidal-marsh complex, the restoration activities planned for Bair Island provide a unique opportunity for documenting the effects and chronology of events that evolve during the implementation of a tidal salt-marsh restoration. Although similar restoration projects have occurred within the SFB (Cooley Landing, Warm Springs), project development has not been documented to the extent that a specific set of guidelines could be produced for use during subsequent restoration projects. Therefore, the restoration plan, while primarily describing the steps required to produce a successful salt-marsh restoration, also provides a monitoring plan and the testing of hypotheses. These efforts will track the development of the tidal marsh as well as providing valuable information for future restoration projects.

1.1 PROJECT GOALS AND OBJECTIVES

The San Francisco Bay Wildlife Society (SFBWS) and the U. S. Fish and Wildlife Service (USFWS) developed goals and objectives for restoration of Bair Island. These goals and objectives, presented below, are consistent with the policies of the Don Edwards San Francisco Bay National Wildlife Refuge, to which Bair Island now belongs.

We assume a 50-year planning horizon, consistent with that used by other San Francisco Bay restoration projects currently in planning.



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Bair Island Restoration Project Monitoring Plan: Vicinity Map

File No. 1697-02	Date 2/18/03	Figure 1

Goals of the Bair Island Restoration Project

- Restore Bair Island to native tidal salt-marsh habitat.
- Provide habitat for endangered and other natives species.
- Enhance the public's appreciation and awareness of the unique resources of Bair Island.

Objectives for the Bair Island Restoration Project

- Restore and enhance habitat for the endangered California Clapper Rail (*Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris*).
- Create and enhance habitat for the endangered California Least Tern (*Sterna antillarum*), California sea-blite (*Suaeda californica*), and other wetland dependent species, if compatible with restoration for the Clapper Rail and harvest mouse.
- Minimize disturbance to sensitive species (e.g., Clapper Rails, harbor seals [*Phoca vitulina*]).
- Provide the control of undesirable species including invasive plants, undesirable predators, and mosquitoes.
- Enhance the public's awareness of the unique resources at Bair Island by providing opportunities for wildlife-oriented recreation and nature study.

1.2 PROPOSED RESTORATION DESIGN

The proposed action restores full tidal inundation to Inner, Middle, and Outer Bair. For Middle and Outer Bair, natural estuarine sedimentation will raise the marshplain surface to allow complete vegetation establishment over time. Restoration will include features to encourage reestablishment of the natural tidal drainage network and discourage the capture of tidal flows by borrow ditches at these two islands. At Inner Bair, dredged material, most likely from Redwood Creek, will be used to raise the marsh plain elevation prior to breaching. Placement of dredged material has the additional advantage of expediting the establishment of emergent marsh vegetation.

Channel modifications would be made at Smith and Corkscrew sloughs to minimize project related effects on high sedimentation rates in the Redwood Creek shipping channel and flow velocities at Pete's Outer Harbor. These channel modifications include the realignment of Smith Slough to its historic meander through Inner Bair and the partial blocking of Corkscrew Slough to the east of the Middle Bair breaches. For details of these project design features please see the Bair Island Restoration and Management Plan (H.T. Harvey & Associates 2002).

Middle and Outer Bair Islands. Levees will be breached at selected historic slough channel locations on Middle and Outer Bair islands, restoring natural tidal flows. Pickleweed-dominated marsh vegetation will establish quickly in areas already at high intertidal elevations. Natural estuarine sedimentation on the lower mud-flat areas will gradually build up these areas to elevations high enough for the establishment of cordgrass and pickleweed. Borrow-ditch cutoff berms will be created to prevent tidal capture by the existing borrow ditches, allowing the natural channel system to re-establish. Interior berms and levees will be lowered or removed where possible, creating additional tidal habitat. Levees desired for upland refuge habitat or required to protect infrastructure from wind-wave erosion would be left in place.

Based on initial ground elevations and predicted sediment supply, some vegetation colonization will begin immediately following restoration implementation. Most of this marsh formation will occur along the perimeter of the restoration areas, along historic slough channels or on higher elevation areas. Substantial tidal marsh vegetation establishment is expected at Outer Bair within 30 to 50 years and at Middle Bair within approximately 50 years.

Inner Bair Island. Dredged material, or other sources of fill, would be used to expand the southern levee of Inner Bair Island to adequately protect the SBSA sewer line and create a cross-levee that protects the San Carlos Airport property on Inner Bair Island. Levees will be breached at historic slough channel locations on Inner Bair Island and borrow ditch cutoff berms will be created to prevent tidal capture by the existing borrow ditches. Although historic slough channels and borrow ditches may be filled with dredged material, differential settlement of the dredged material will result in a lower elevation, and therefore channel development may still occur in these areas.

Fill will be used to raise ground levels on Inner Bair from current elevations of approximately 0.0 to between 2.0 and 3.0 feet NGVD, requiring between 400 – 500,000 cubic yards of fill. This target is close to the 538,000 cubic yards dredged from Redwood Creek during an average dredging event. Redwood Creek has been dredged eight times between 1977 and 1999, and the average annual accumulation rate is estimated to be 200,000 cubic yards.

The area within the cross-levee system protecting the San Carlos Airport safety zone, as well as the alignment of the SBSA sewer line, will be filled with dredged material to an elevation that is above MHHW. By creating upland and transitional habitats in these areas, some of the primary constraints associated with reintroducing tidal action to Inner Bair Island are minimized. From the created upland areas, the fill material will gradually slope down to the lower elevations of the restored marshplain. Fill elevations will be highly varied, ideally providing ample areas of transitional habitat, including upland, seasonal wetland, and supratidal wetland areas. The lower elevations will be high enough for pickleweed and cordgrass to immediately colonize once the site is breached, but low enough to allow some channel development through natural tidal scour. A limited number of perennial pickleweed starter plantings will be installed. Potential drawbacks of dredged material placement are cost and impaired tidal channel development at Inner Bair (as the existing remnant slough system may be covered). Sediment quality would also need to be appropriate for wetland reuse.

No public access will be allowed on Outer and Middle Bair Island except by Refuge guided trips and other specific exceptions that are approved by a Refuge Special Use Permit. Public access for pedestrians and bicyclists will be allowed along a 2.7-mile levee trail on Inner Bair. This trail will be provided along the perimeter of Inner Bair, running from the Refuge's parking lot near Pete's Harbor. An orientation kiosk and viewing/environmental education platforms will be provided at the ends of the levee trail, adjacent to Smith Slough.

Fishing from boats in Smith, Corkscrew and Steinberger Sloughs and Redwood Creek will be allowed, however fishing will not be permitted from land. Hunting of waterfowl on Outer Bair Island will be allowed per state regulations.

1.3 PROJECT TIMELINE

It is anticipated that Bair Island Restoration project will be implemented in 2005. The project is large scale and therefore will be implemented over a period of several years.

1.4 MONITORING OBJECTIVES

The objectives for the monitoring program are to ensure the restoration meets the project's objectives by achieving the goals stated above. Adaptive management decisions based on monitoring data will increase the potential for project success, especially since tidal restoration at Bair Island will be implemented in phases. One additional objective is to provide data for future, tidal, salt-marsh restoration projects in San Francisco Bay.

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Bair Island Restoration Project Monitoring Plan:
Restoration and Reference Site Map

File No. 1697-02 | Date 12/17/03 | Figure 2

2.0 MONITORING ELEMENTS

Specific monitoring elements that will provide information for evaluating the evolution of site functions have been identified. These monitoring elements have been selected as pertinent indicators of progress towards the project's specific goals and objectives.

2.1 MONITORING LIMITATIONS/ASSUMPTIONS

There are no specific performance criteria for the Bair Island Restoration project. However, the restoration project was designed to achieve overall objectives of restoring Bair Island to native tidal salt-marsh habitat, and providing habitat for endangered species (California Clapper Rails and salt marsh harvest mice). Monitoring of the restoration project will facilitate evaluation of the project's progress towards achieving those objectives.

Certain elements of the plan, especially some of the physical elements, will be discontinued, once there is a clear indication that the site is evolving in the predicted fashion, as described below. It is likely that the distinct subsections, or "ponds" (Inner Bair, Middle Bair East, Middle Bair West, and Outer Bair), within this restoration will achieve their objectives in different time frames. Therefore, this monitoring program will end within each pond once California Clapper Rails and salt marsh harvest mice have colonized that unit.

2.2 PHYSICAL ELEMENTS

Physical monitoring will be carried out at specified intervals to help to understand how the physical system is responding to the restoration design implementation and to determine if any intervention is required. This part of the monitoring program includes several geomorphic and hydrologic elements that will be monitored by a qualified engineer or geomorphologist. Monitoring locations are shown in Figure 3 and 4. The monitoring schedule and frequency are described in Table 1 of Section 4. The exact locations of the monitoring data will be determined by Global Positioning Systems (GPS) to facilitate accurate mapping.

Tidal Circulation. Water levels and drainage patterns will be monitored in the tidal sloughs and inside the restored ponds to evaluate hydrologic functions at the site. Tidal circulation is important since characteristics of the hydroperiod affect vegetation colonization, sediment delivery to the marshplain, ecologic functions of the site, and drainage of adjacent low-lying areas.

Tidal damping conditions in slough channels and restored ponds are expected during initial tidal restoration of Middle Bair because parts of the slough network will be initially undersized and because the new flow-control structures will reduce the amount of tidal flow routed through Redwood Creek. Initially, Inner Bair, Middle Bair, and the upstream reach of Steinberger Slough are not expected to drain completely at low tide. However, low-tide drainage is expected to improve as the sloughs deepen and internal drainage networks inside the ponds develop.

figure 3

Bair Island

Monitoring Stations:
Tide Gauges & Current Velocities

Basemap: aerial photograph (2/18/00)

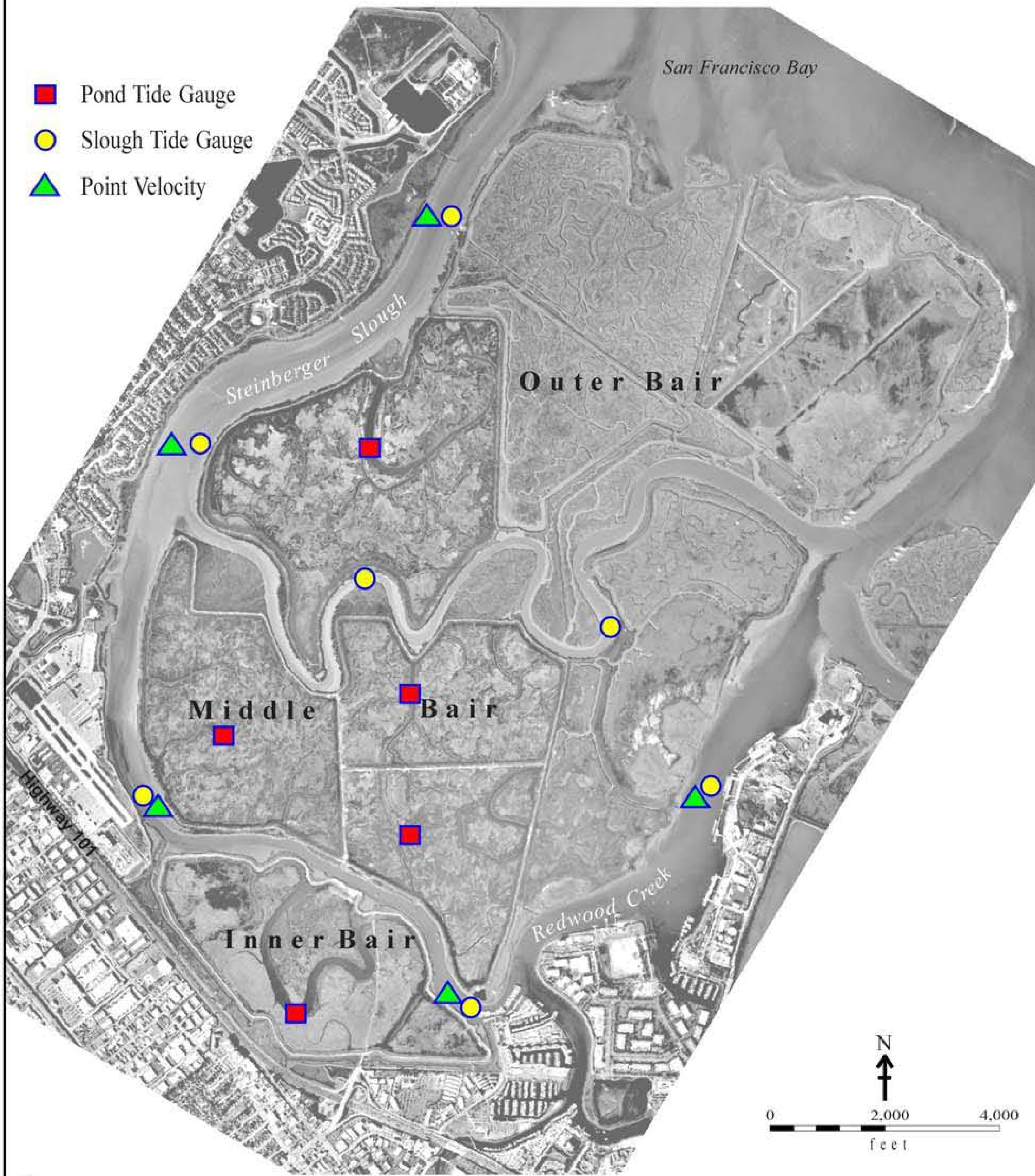

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figure 4

Bair Island

Monitoring Stations:
Slough and Marsh Morphology

Basemap: aerial photograph (2/18/00)

PWA

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Water-level elevations will be measured continuously over a spring neap cycle (about 14 days) concurrently at locations within the slough network and inside Outer, Middle, and Inner Bair Islands. Water-surface elevation data will be used to determine whether tidal damping is present inside the sloughs and ponds. If the monitoring team concludes that tidal dampening is present and poses a significant threat to site development, then remedial measures will be developed and proposed in the monitoring reports. Internal levees, ditch blocks, under-sized sloughs, and slow re-establishment of the historic pond channels are examples of conditions that may contribute to inadequate low-water elevation drainage.

Slough Morphology. The goal of the slough morphology monitoring is to understand how the existing looped slough networks of Redwood Creek, Steinberger Slough, Corkscrew Slough, and Smith Slough (Figure 4) are responding to the tidal restoration project. Increased tidal flows are expected to erode sections of Steinberger Slough, while decreased flows due to flow-control structures are expected to cause siltation in other portions of the slough system. These trends of erosion and siltation will influence water levels at the site and conveyance of flood flows from Pulgas and Cordilleras Creeks.

Steinberger Slough is currently undersized to convey the additional tidal prism associated with restoration of Inner, Middle, and Outer Bair, and is expected to deepen as increased tidal flows scour sediment. Bed erosion is likely to occur preferentially along the thalweg, where velocities are greatest, resulting in improved low-water drainage in the upstream reaches of the slough and in areas of Middle Bair that drain to Steinberger Slough. Increased conveyance along Steinberger Slough will be necessary to offset decreases in conveyance associated with rerouting streamflow from Pulgas and Cordilleras Creeks that presently discharge to San Francisco Bay through Redwood Creek. Targeted cross sections of Steinberger Slough will be surveyed more frequently than other parts of the slough network to assess morphological changes that affect its ability to route flood flows. This more frequent flood assessment will include numerical modeling to establish changes in flood conveyance along Steinberger Slough, as described in the EIR/S.

As described in PWA (2003), a revised flood assessment may be required if monitoring of water levels indicates that the channel restrictors are not performing as expected (i.e., the amount of tidal flows in the Redwood Creek and Smith Slough are significantly higher than existing conditions). If a revised flood assessment is required, cross sections will be surveyed along Steinberger Slough, at the locations shown in Figure 4. Significantly fewer (approximately half) cross sections will required if a revised flood assessment is not required. Data form cross sections along Smith and Corkscrew Sloughs will also be collected, although less frequently. Additionally, cross section data will also be collected along Redwood Creek to document whether or not tidal restoration of Bair Island has increased the shoaling rate along the Shipping Channel. Cross sections will be surveyed before restoration (Year 0) at every monitoring station to establish baseline conditions and at the time intervals shown in Table 2 in Section 4.

Satellite imagery collected for habitat evolution (see below) will also be used to assess morphological changes along Steinberger Slough, especially at its mouth where substantial erosion through the outboard mudflat is expected.

Marsh Morphology. The morphology of the restored marshplain will be monitored to measure whether the site is evolving along the expected trajectory. Since it is expected to take many decades for the site to reach elevations close to those of natural marshes, monitoring will provide data that can be used to estimate the rate of evolution and the functions of the restored wetland in its transitional state. Components of the marsh monitoring include:

1. Pond Drainage Network. In the current pond configuration, historic pond channels and some of the borrow ditches in the interior of the ponds are expected to capture most of the tidal flows onto the marshplain, therefore the restoration design includes channel connectors and "cut-off berms" to allow for adequate drainage without the borrow ditches becoming the primary drainage network. In order to track slough development during restoration, approximately one to five cross sections of each selected remnant channel will be surveyed. Figure 4 shows the pond channels recommended for survey, although the exact location and number of cross sections may be modified depending on how the restoration project is implemented (e.g., phasing) or adaptively managed as the site evolves. Longitudinal profiles will also be collected along the main interior channels identified in Figure 4. "Cut-off berms" will be visually inspected to evaluate whether they are performing adequately (not undermined by excessive erosion) and whether any maintenance is required. One cross section will be collected from a borrow ditch adjacent to each of the primary pond channels. Additionally, aerial photography collected for habitat mapping will be used to assess the evolution of the interior pond drainage system.

2. Marshplain Evolution. Tracking the development of the restored marshplain will be a key monitoring element, given the overall goals of the restoration project. Sedimentation plates/pins will be installed prior to breaching and inspected after restoration to determine rates of estuarine deposition. Stations will be installed throughout Outer, Middle and Inner Bair islands to determine how sedimentation rates vary with distance from levee breaches and among the three ponds. Additionally, vegetation-elevation transects approximately 500 – 1,000 feet long will be surveyed to verify sedimentation rates and further characterize marshplain evolution, particularly the natural levee formation behind the interior pond channels.

3. Breaches. Since Middle and Outer Bair Islands will be below natural marshplain elevations at the time they are breached, a greater amount of tidal prism will initially pass through the levee breaches relative to long-term conditions. Therefore, there may be a tendency for the breaches to scour and enlarge, since they were sized based on the expected long-term conditions. Cross sections of each of the nine levee breaches included in the Recommended Alternative will be measured to determine the rate of breach widening and deepening.

4. Remnant Levee. Although some levees on Middle and Outer Bair will be lowered to provide a source of fill for construction, outboard and interior levees will largely be left in place to serve as wave breaks to promote marshplain evolution and provide upland refugia for marsh wildlife. Levees will be inspected for evidence of wind-wave erosion by aerial photography, and the linear distance of intact levees will be estimated.

Tidal-Current Velocities. The potential for increased tidal-current velocities at Pete's Harbor was identified as a significant project constraint early in the restoration design development. Specific elements were included in the design to facilitate tidal restoration without raising peak velocities at the harbor. Point-current meters will be used to measure tidal currents before and following tidal restoration to confirm velocities are not significantly higher following restoration. Additional current meters will be deployed along Steinberger and Corkscrew Sloughs to correlate velocities with rates of erosion and downcutting. Figure 3 shows the locations of each tidal-current station. Tidal-currents will be measured over a complete spring neap cycle and timed to coincide with measurements of water level elevations.

Infrastructure. Flow-control structures along Smith and Corkscrew Sloughs will be visually inspected to assess structural integrity and to confirm that these elements are functioning as expected. The structural integrity and hydraulic performance of the flow-control structures are essential to project success, since the structures limit sedimentation along the Redwood Creek Shipping Channel and enhance the supply of sediment-laden water to Middle and Outer Bair islands. The armored breach along the historic meander of Smith Slough (IB1) will also be inspected at the same time as the flow control structures. As described in the Restoration and Management Plan (HTH & PWA 2003), adjustments to the flow control structures and armored breach will be made as part of an adaptive management program to ensure the restoration plan does not adversely affect flood hazards or the shipping channel. Trails will also be visually inspected to assess their structural integrity.

Monitoring Schedule. Monitoring of physical elements should follow the schedule summarized in Table 1 in Section 4. Note that some of the monitoring elements can be discontinued early, if data indicate that performance is satisfactory.

2.3 BIOLOGICAL ELEMENTS

Habitat Mapping. To determine ratios of intertidal habitats to each other and to open water, satellite imagery (*e.g.* IKONOS) will be obtained for the project area. The image will be collected in June or July, during a low solar angle, and minus tide. To ensure comparisons across years, all image capture will occur at a similar tidal elevation. The monitoring schedule and frequency are described in Table 1 of Section 4. It is essential that the type of image and parameters of the images stay essentially the same both within and across years to spatially analyze the data. The imaging for the first five years will primarily be used to help monitor physical changes on the marsh plains, as little vegetation colonization is expected in that period.

Habitats will be mapped on a dominant species basis, primarily to detect colonization by native cordgrass and pickleweed. Non-native cordgrass will also be mapped, where it can be detected on the satellite images. The images will be interpreted and mapped preliminarily, then ground truthed from levee locations and by boat.

Vegetation. More detailed plant sampling will occur along the established transects only after the aerial mapping has detected the beginning of colonization. Specifically, when habitat mapping indicates that the percent cover of vegetation on the marsh plain in a given pond (Inner, Middle East, Middle West, or Outer Bair) equals or exceeds 10%, then more detailed sampling will be conducted. That sampling will occur thereafter every 5 years until successful colonization of each pond by CCR and SMHM is confirmed. Plant-species composition and relative abundance will be determined in minimum one square meter quadrats arranged along the vegetation/elevation transects shown on Figure 4. Quadrat sampling will correspond with elevational data points collected on the transects.

The best timing for vegetation sampling is July or August, however this period conflicts with protections afforded to the California Clapper Rail during the breeding season. Therefore, it is understood that sampling may not occur until September of each year. The monitoring schedule and frequency are described in Table 1 of Section 4.

Invasive Cordgrass. The San Francisco Estuary Invasive *Spartina* Control Program proposes to implement a coordinated, region-wide eradication program, comprising a number of on-the-ground treatment techniques to stave off invasion of non-native cordgrass from the eastern United States. The Control Program would be focused within the nearly 40,000 acres of tidal marsh and 29,000 acres of tidal flats that comprise the shoreline areas of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma, and Sacramento counties. One of the initial targets of the program includes Bair Island. It is assumed that all invasive cordgrass monitoring and eradication will be coordinated through this control program.

However, if invasive cordgrass is suspected and/or identified along an established vegetation transect or during general site reconnaissance, the location of the invasive cordgrass will be mapped and reported to the Control Program. The project proponents are working closely with the San Francisco Bay Invasive *Spartina* Control Program to ensure that any activities at Bair Island are consistent with the goals and procedures of the bay-wide eradication program.

Adaptive Management. Three years after tidal influence has been restored to Bair Island the extent of the invasive smooth cordgrass (*Spartina alterniflora* and its hybrids) infestation will be re-evaluated and the challenge and feasibility of eradicating the introduced cordgrass will be re-assessed in relation to conditions in the South Bay and Control Program's regional efforts of smooth cordgrass control. At this time it may be deemed infeasible to eradicate the invasive species in perpetuity. If this is the case, efforts may focus on controlling smooth cordgrass spread, maintaining areas of open mudflat and insuring that it is not encroaching on higher marsh habitat.

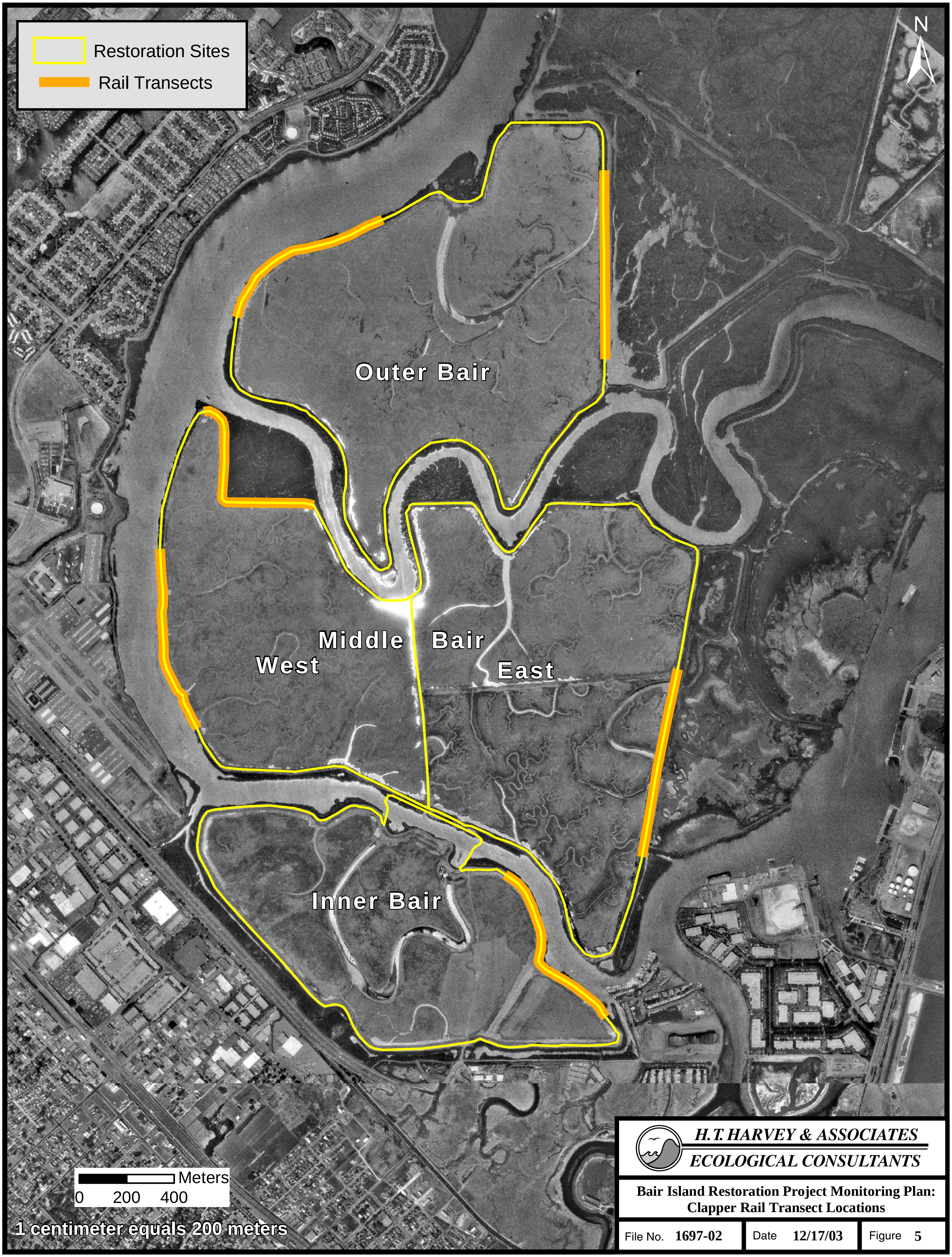
California Clapper Rail. A primary goal of the restoration of Bair Island is the creation of habitat for California Clapper Rails. Clapper Rails currently breed on the restored portion of Outer Bair Island. Clapper Rails also breed on nearby Greco Island.

Studies of radio-tagged individuals representing three other subspecies, including the Louisiana, Light-footed, and Yuma Clapper rails (*R. l. saturatus*, *R. l. levipes*, and *R. l. yumanensis*, respectively; Roth et al. 1972, Zembal et al. 1989, Conway et al. 1993) have shown that these rails have relatively small home ranges ("territories" - 0.04 – 1.66 ha), but that their territories change seasonally, being significantly larger during the nonbreeding period than during the breeding season. These rails are most vocally active during the early breeding season (March to May) and least active during winter (Conway et al. 1993). The latter is the only study that we are aware of that examines seasonal vocalizations of this species, but the seasonality noted by these authors is consistent with that of another species, the California Black Rail (*Rallus jamaciensis corturniculus*; Spear et al. 1999). In addition, detection probability in the California Black Rail, and likely the Clapper Rail as well, is related to several environmental factors including time of day, air temperature, cloud cover, tide height, moon phase, and season (Spear et al. 1999). Except for time of day (see below), we are not aware of such studies having been conducted for the Clapper Rail.

The objective of the Clapper Rail surveys at Bair Island is to determine presence and estimate densities. Breeding season surveys will be conducted every five years beginning when vegetation monitoring detects 30% cover and continue until the USFWS determines that a sustainable population of Clapper Rails breeds in the restored areas. A target breeding season density can be 0.33 rails per hectare of marsh habitat, a mean density derived from an extensive study of breeding California Clapper Rails conducted in 13 marshes in the South Bay in 1989 (H. T. Harvey and Associates 1989). The USFWS will also use the monitoring data to track the rail population in the restored habitats and implement adaptive management as determined necessary by the Service. Once the USFWS determines that a sufficiently robust breeding population of California Clapper Rails is established in the restored areas, the Service will continue monitoring the areas via winter high-tide surveys. Breeding season surveys should be conducted between February 15 and April 15. As noted above, this period coincides with the first part of the breeding season when rails are most vocal and detectability rates are likely at a maximum which, in turn, maximizes the accuracy of density estimates derived from survey data.

Clapper Rails will be surveyed at Outer, Middle-east, Middle-west and Inner Bair Island using 800 m long (0.5 miles) transects positioned on the diked levees (Figure 5). Each transect will consist of 5 stations at 200 m intervals. Each of the 30 stations will be marked with a flagged rebar post with the transect and station numbers labeled on the flagging. Placement of transects within each survey area will be determined based on optimum habitat quality at that time. Surveys will be conducted on each transect three times, with surveys at least one week apart. During each survey session, multiple observers can survey more than one transect simultaneously, as long as: 1) there is not more than one observer assigned to any given section and, 2) they are spaced far enough apart so that call-broadcasts (details below) cannot be detected by any of the other observers involved. Thus, it is likely that a total of three observers could conduct surveys simultaneously. In the past we have found that the problem of an observer mistaking the other's recorded calls for a rail can be avoided by choosing transects separated by distances >2000 feet (about 0.4 miles).

Surveys will be conducted using pre-recorded "duet" calls of the California Clapper Rail. Each observer will need an ESA section 10a1A "recovery permit" to broadcast rail vocalizations, as the activity constitutes "harassment" of a Federally-listed species. These permits are available from the U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, 2800 Cottage Way, Room W-2605, Sacramento, CA 95825. Obtaining these permits well before survey implementation will be very important because without the use of broadcasts, considerably more time will be required for "listening" at each station and rail densities are more likely to be underestimated. Even more critical would be the unrecoverable loss of the standardized survey protocol (a must for population trends analyses) that will occur if broadcasts are used in some years but not others.



Bair Island Restoration Project Monitoring Plan: Clapper Rail Transect Locations

File No. 1697-02 | Date 12/17/03 | Figure 5

The calls will be broadcast at each station for one minute, with four sequences of duet or clapper calls repeated during the playback minute. Each observer will require a high-quality cassette (or CD or MP3) player equipped with a stereo-amplified speaker system capable of broadcasting between 80-90 dB at 1-meter in front of the speaker, and a high quality recording to broadcast rail calls. The same audio setup played at a standardized decibel rating will be used on every survey. For each survey, starting points at either end of all transects will be alternated. Morning surveys should not be initiated earlier than 0.75 hours before sunrise or end more than 1.25 hrs thereafter, and evening surveys should begin no earlier than 1.5 hrs before sunset and end no later than 0.75 hours following sunset (Zembal et al. 1989, Spear et al. 1999). An hour should be adequate to complete the survey along each transect if observers spend no more than 10 minutes at each station.

Following Kepler and Scott (1981), observers will be trained to estimate detection distance. These training sessions will be conducted prior to surveys using a recorder playing rail vocalizations at various distances from the observers. Each detected Clapper Rail will be counted and the distance to each bird will be estimated. The distance from observers at which rail detection probabilities decrease will be established using standard equations. This information will then be used to calculated Clapper Rail densities. Thus, both direct-count and density data will exist for each area surveyed.

Weather conditions, including wind speed and direction, air temperature and cloud cover will be recorded at the beginning of each survey. Surveys should be discontinued when winds are >15 knots. Surveys will not be conducted when tides are greater than 4.5 feet NGVD as measured at the Golden Gate. Except for wind speed, it will not be possible to control for the effects of other environmental variables that affect rail detection probability (e.g., tide height, air temperature, cloud cover, and moon phase) due to logistic constraints imposed on the scheduling of rail surveys. But by recording these variables during surveys, it will be possible to make the required adjustments during the analyses of Clapper Rail density (see below).

When a Clapper Rail is detected during surveys, data recorded will include date, time, station number, type of call, compass bearing and estimated distance to the calling bird. Distance estimates will pertain to the first call elicited by a rail. Simultaneous vocalizations and distances between call locations will be used to distinguish individuals.

Post restoration, monitoring will begin at any one of the four subsections only after the vegetation targets area reached. They will continue at the specific transect until CCR densities reach the target level (Table 1, Section 4)

Salt Marsh Harvest Mouse. The objective of the SMHM monitoring is to achieve a consistency in catch within each restored pond so that we can reasonably assume that SMHM are establishing a viable population within the restored portions of Bair Island. We considered a variety of trapping programs and techniques while designing the monitoring element for the SMHM. For example, protocols collected by SFEI (2002) included both random and non-random protocols for monitoring salt marsh harvest mice; the former, with its random assignment of trapping locations, allows for detailed statistical analysis of such parameters as microhabitat use but requires large numbers of trap nights and is time, effort and cost intensive. The latter protocol, i.e., using non-random techniques such as grids and/or lines of traps, can be used to ascertain presence and absence of salt marsh harvest mice and provide qualitative data as to relative usage of various areas by the mouse. Non-random techniques, however, are not amenable to most statistical analyses but require fewer trap nights, and less time, effort and cost.

We propose to use the non-random method because of the number of areas and trap nights to be monitored, the concentration of traps needed to trap this species when it is present in low numbers, and the narrow time window available for trapping (i.e., when Clapper Rails are not nesting and nighttime tides are low). Therefore, the trapping protocol is designed to detect the colonization of the restored marsh by SMHM, and the establishment of a population within the restored area. A population will be considered established when relative densities, as judged by capture efficiency (capture per unit effort, CPUE), approximate other marshes in the south bay area. Data collected by Shellhammer and Duke (in preparation) indicates that 3 captures per 100 trap nights would be a reasonable indication that a population had established itself on the restored marsh plain.

Monitoring will commence when pickleweed cover reaches at least 75% cover over at least 10% of the developing marshplains within any subsection (i.e., Inner, East and West Middle, Outer) of Bair Island (see Vegetation monitoring element). While dense patches of pickleweed over 10% of any given pond is far less than its projected final distribution, this represents 30 to 140 acres, depending upon the pond. Trapping will occur initially only in the section with the best potential habitat and will be conducted on the marsh plain. Special precautions need to be observed in order to trap on the marsh plain. Trapping will have to occur in a neap tide window in the fall when the marsh plain supporting pickleweed will not be inundated for the 4-day window of trapping.

Because these sites are large and there is likely considerable spatial variation in mouse abundance, two grids (lines) of 50 traps (spaced 10 m apart, 100 total traps) will be established within each pond, within the best available habitat. If possible, the grids will overlap with vegetation/elevation transects established on the marsh plain. Each grid will be trapped for four nights. Trapping will continue every five years until SMHM are captured on the restored marsh plain and in sufficient numbers (see below) to conclude that the population is established.

All trapping will be conducted using Sherman live-traps. Live traps will be supplied with nesting material and baited, and each trap will be placed on a small wooden board to shield nesting material (cotton batting) from wicking moisture from the substrate. A second board should be placed on top of any trap not sufficiently covered by vegetation. Trapping dates will be selected to avoid inclement weather, and be based on periods when overnight tides will be least likely to inundate set traps. Traps will be checked each morning at dawn, closed and removed (if necessary) during the day, and reset one hour before sunset.

Trapping will be conducted by trained and permitted biologists following all federal and state permitting guidelines. All small mammal species will be identified and sexed while salt marsh harvest mice will also be weighed and marked to allow assessment of recapture on subsequent trap-nights during the trap session. Methods described in Shellhammer (1984), and the Don Edwards San Francisco Bay NWR protocol will be used to identify *Reithrodontomys* mice to species whenever possible.

Each trap will be marked with the transect and trap number and GPS units will be used to record the location for each trap. Each time a mouse is trapped the transect and trap number will also be recorded. Vegetation data will be recorded at each trap site within each grid. Minimum vegetation data collected will be species present, percent plant cover by species, maximum plant height by species. All vegetation data will be collected within a 1-m^2 quadrant. The southeast corner of the quadrat will be located on the trap site.

Introduced Predators. Introduced predators such as the non-native red fox (*Vulpes vulpes regalis*) can have significant negative effects on nesting birds, including California Clapper Rails. Restoration of Clapper Rails cannot occur without concurrent management of non-native predators, thus red foxes and other mammalian predators will continue to be trapped at Bair Island following guidelines in the USFWS (1991) Predator Management Plan and Final EA. Although no formal monitoring will be established for introduced predators, if Clapper Rail surveys or other anecdotal evidence suggests that introduced predators are present at Bair Island, a monitoring program should be established following the methods of Albertson (1995).

3.0 DATA ANALYSIS

3.1 ANALYSIS OF PHYSICAL DATA

Analysis of field data collected during each monitoring event will be conducted as soon as possible to allow for further sampling if discrepancies in the original data set are encountered. Data analysis will include preparation of graphs and tables, and comparisons with previous monitoring events to evaluate site progress. Specifically, analysis of the physical data will include the tasks described below.

Tidal Circulation. Data from the tide gauges will be presented graphically and compared with tides in San Francisco Bay to assess the degree of tidal muting throughout the slough system and ponds. In particular, the low-water elevation during spring and neap tides will be examined at the monitoring locations. Tide signals from the gauges installed inside the restored ponds will be compared to marshplain elevations to determine frequency, duration, and depth of flooding. An assessment regarding the adequacy of site drainage in relation to habitat development will be made.

Slough Morphology. Measured cross-sections will be presented graphically, and the rates of downcutting and widening will be documented. Data collected from the point current meters will be compared to rates of erosion/sedimentation along the sloughs. The amount of slough expansion following tidal restoration will be important in assessing the risk of flooding along Pulgas and Cordilleras Creeks (briefly discussed below and detailed in the EIR/S).

Marsh Morphology. Marshplain sedimentation rates collected from the sedimentation plates/pins will be used to assess if the site is evolving as expected, and to estimate the time required to reach a mature marshplain elevation. Data will be tabulated for each of the monitoring locations to document the variability in sedimentation rates throughout the site. Transect data will be presented graphically and compared to elevations required for vegetation colonization.

Data for breach cross-sections will be presented graphically, and rates of widening and downcutting will be determined. Data from tide gauges installed in the restored sites will also be examined to explain adjustments in breach geometry.

Tidal-Current Velocities. Data from the point-current meters will be presented graphically, and peak spring and neap velocities will be noted. Peak tidal current velocities collected at Pete's Harbor will be compared to pre-project conditions to assess whether tidal restoration at Bair Island has resulted in higher tidal currents and more difficult navigation conditions.

Current velocities along Redwood Creek will also be compared to pre-project conditions to determine if more sediment-laden Bay water is being drawn through the shipping channel. Some natural variability is expected due to differences in tidal forcing at the time of monitoring and timing of dredging activity, and surveyed cross sections along Redwood Creek will supplement the assessment of increased shoaling in the shipping channel.

Since monitoring of velocities at Pete's Harbor and along Redwood Creek will be carried out to document the need for mitigation, a more detailed description of the data analysis is provided in the EIR/S documents.

Peak tidal current velocities collected along Steinberger and Corkscrew sloughs will be documented and compared to the observed rates of erosion/deposition to help define erosion thresholds.

Performance of Hydraulic Structures. Measured tidal currents collected from Pete's Harbor, Redwood Creek, and Corkscrew Slough (east of the flow control structure) will be compared to pre-project conditions to determine if flow-control structures are functioning properly. Specifically, measured tidal currents and surveyed cross sections will be used to assess the effectiveness of flow-control structures in limiting tidal flows through Redwood Creek and routing the additional tidal prism through Steinberger Slough.

Flood-Risk Assessment. An annual flood-risk assessment will be conducted by examining the low water drainage along Steinberger Slough and supplemented by numerical modeling. Although bed erosion is expected to improve low-water drainage and conveyance, the initially undersized cross sections of Steinberger Slough are expected to increase flood hazards in the short-term. Since the annual flood assessment will be carried out to monitor for mitigation of increased flood hazards, the assessment is detailed in the EIR/S documents.

Trail Assessment. Visual inspections of the constructed trails will be used to assess: (1) if trail cover is appropriate for the level of traffic, (2) if public safety and access have been maintained, and (3) how off-trail use is adversely affecting wildlife habitat and the possible need for trail re-alignment.

3.2 ANALYSIS OF BIOLOGICAL DATA

Habitat Mapping. Habitat mapping data will be analyzed in GIS to determine the area of each habitat type and changes in habitats through time. The percent change in habitats through time will be analyzed using a spatial analysis program. This analysis will allow project managers to track the development of habitats.

Vegetative Cover. The sampling unit to be analyzed will be a species' relative cover value, by transect. These data will be used to trigger sampling for SMHM and CCR.

Invasive Cordgrass Monitoring. Non-native cordgrass stands identified during sampling will be reported directly to the San Francisco Bay Invasive *Spartina* Control Program.

California Clapper Rail. Estimating abundance of rails from call playback surveys requires the determination of the maximum range within which rails are detected with equal probability (see Buckland et al. 1993). The expected number of detections increases in proportion with πr^2, where r is the distance between the observer broadcasting the calls and the outer edge of the survey zone (i.e., the radius of the circular survey zone), and π is the constant, 3.1416. Conformance in the number of rail detections with this relationship as r is increased indicates that rails are being detected at the farther distances as well as they are at closer ones. Conversely, a breakdown in the relationship caused by a decrease in rail detections at larger distances indicates that detection probability is being negatively affected by the increase in r, either because the observer is hearing fewer of the responding rails, or because fewer rails at those greater distances are responding to the broadcasts.

An example of avian density calculations is given below, assuming that the detection range cutoff is 50 m. The density for each transect survey will be calculated from the equation:

$$d = \frac{n}{(\pi)(50^2)(5)},$$

where d = the number of birds of species a per meter^2, n = number of detections within 50 m, π = 3.1416, and 5 is the number of stations per transect. Annual mean density of species $a \pm$ the standard error can then be calculated by averaging density across x transects conducted per year. An abundance estimate, then, is the density times the surface area of the marsh for which an estimate is desired.

Salt Marsh Harvest Mouse. The sampling unit will be catch per unit effort (CPUE) per grid. CPUE will be compared among the different subsections of Bair Island, and with other historic and current data from South San Francisco Bay, but 3% CPUE is the initial target. Changes in mouse densities between sampling years will be analyzed qualitatively. Relative plant abundance and plant height will also be qualitatively compared to SMHM densities. Due to sampling design limitations, no statistical tests are planned for SMHM density estimates.

Introduced Predators. No analyses are planned for predator observations.

4.0 MONITORING TIMELINE

All monitoring elements described in Section 2 should occur at the frequency listed in Table 1. Selected monitoring can be discontinued if data indicate that site evolution and/or the hydraulic structures are performing as expected, as discussed below. Efforts will be made to coordinate and consolidate monitoring effort once the monitoring triggers have been attained.

Table 1. Monitoring Frequency of Physical Elements

ELEMENT	FREQUENCY	NUMBER OF STATIONS/GAUGES/TRANSECTS*
Tidal Circulation	Years 0, 1, 2, 5, 10, 15, 20***	7 tide gauges in the slough system and 5 gauges in the Outer, Middle and Inner Bair Islands.
Slough Morphology**	Years 0, 1, 2, 5, 10, 15, 20.	18 cross sections throughout slough network.
Targeted Survey of Steinberger Slough	Annually, to be discontinued once flood assessment indicates that conveyance has been restored (see text)	3 tide gauges and 9 cross sections along Steinberger Slough (to assess changes in flood conveyance).
Marsh Morphology	Years 0, 1, 5, 10, 15, and 20	9 levee breaches, 6 transects, and 7 sedimentation plates/pins.
Current Velocities	Years 0, 1, 2, 5, 10, 15, 20 ***	5 current meters.
Infrastructure	Flow control structures and armored breach immediately after construction and significant rainfall events during the first year, then twice a year (before and after the rainy season). Trail annually.	2 flow control structures, 1 armored breach, and trails along Inner Bair Island.
Habitat Mapping	Years 0, 1, 5, every 5 years until CCR and SMHM monitoring criteria are met	Satellite imagery, field-truthed and produced in GIS
Vegetation	Variable depending upon site evolution. Begins when habitat mapping detects 10% cover, then every 5 years thereafter until CCR and SMHM monitoring criteria are met	6 transects, corresponding to marsh morphology transects.
Invasive Cordgrass	See Vegetation (above)	N/A
California Clapper Rail	Breeding season surveys initiated when vegetation cover in restored areas	Call playback surveys will be conducted along transects on the levees of the restoration site.

ELEMENT	FREQUENCY	NUMBER OF STATIONS/GAUGES/TRANSECTS*
	reaches 30%. Then once every five years until breeding densities reach 0.33 rails/hectare, or the USFWS determines that an adequate breeding population has been established. Thereafter, winter high-tide surveys will be conducted.	
Salt Marsh Harvest Mouse	Begins when dense pickleweed covers 10% in any given pond. Then every 5 years until CPUE = 3%	Two grids on Inner and Outer Bair; four grids on Middle Bair.

* Approximate numbers only. The precise number of monitoring stations may vary depending on data collected during the previous monitoring events.
** See also targeted surveys of Steinberger Slough.
*** See text for discussion of performance criteria for early termination of these surveys.

Low-water drainage is expected to improve as tidal scour deepens Steinberger Slough and a channel drainage networks are established inside the Outer and Middle Bair Islands. Therefore, monitoring of water surface elevations can be discontinued once the full tidal range is developed.

Monitoring of current velocities at Pete's Harbor and Redwood Creek can be discontinued after Outer, Middle, and Inner Bair Islands have been breached, once the data indicate that peak tidal currents to do not significantly exceed pre-project conditions. Monitoring of velocities along Steinberger Slough should continue as long as morphological changes of the slough are observed.

As discussed in the EIR/S, assessments of conveyance of flood flows from Pulgas and Cordilleras Creeks will be carried out every year. Targeted surveys along Steinberger Slough will not be needed once these annual flood assessments demonstrate that scour along this reach of the slough network has increased flood conveyance to pre-project levels.

Note that more detailed descriptions of the flood and Pete's Harbor assessments are provided in the EIR/S.

5.0 PERFORMANCE EXPECTATIONS

Measuring performance of the restoration relative to expectations will increase the likelihood that long-term habitat goals will be met through adaptive management. Since Bair Island is not a mitigation site, it does not need to strictly conform to a particular set of standards. However, the expectations listed in Table 3 will be used to guide evaluation of site evolution. Expectations for meeting non-habitat related mitigation requirements are documented in the EIR/S and are not included here.

Table 2. Performance Expectations

MONITORING ELEMENT	PERFORMANCE EXPECTATIONS (HYPOTHESES)
Tidal circulation and Slough Morphology	Inner Bair, Middle Bair, and the upstream reach of Steinberger Slough are not expected to drain completely at low tide initially. However, drainage will improve as Steinberger Slough deepens and drainage systems inside the ponds develop. The range of high and low tides throughout the site will be similar to those in South San Francisco Bay by approximately Years 5 - 10. This expectation relies on engineering judgment based on rates of tidal slough scour in similar systems. Rates of tidal slough scour erosion are generally difficult to predict with certainty and no site-specific predictions have been prepared for Bair Island. We consider the time frame above (5-10 years) to be conservative, and the actual time for full tidal drainage may be less.
Marsh morphology	The ponds will evolve to more closely resemble a natural marsh. However, rates of colonization of emergent marsh vegetation will vary due to spatial differences in suspended sediment concentration, initial muting of the tide range, and differences in existing elevations within the ponds. Expected habitats and site evolution are described more fully in Section 7.2 of the Restoration and Management Plan.
Current Velocities	Pre- and post-project velocities are expected to be similar east of the flow control structures. Velocities west of the structures are expected to increase.
Tidal marsh vegetation	Inner Bair will rapidly colonize with cordgrass and pickleweed (*Salicornia* sp.), with substantial areas of vegetated marsh forming by the end of Year 5. Inner Bair will likely transition into a perennial pickleweed (*Salicornia virginica*) dominated marsh by the end of Year 15. Outer Bair will be mostly vegetated in 10 to 25 years. Plant establishment at Middle Bair will take longer, with a vegetated marsh forming in 25 to 50 years.
Transition/Upland vegetation	In order to provide high-tide refugia for the salt marsh harvest mouse, the transition and upland vegetation should evolve to provide adequate plant cover. The total acreage of these habitats will depend upon the amount of area created in Inner Bair by the beneficial use of dredge material and by differential subsidence of levees and berms throughout the restoration areas.

MONITORING ELEMENT	PERFORMANCE EXPECTATIONS (HYPOTHESES)
California Clapper Rail	It is anticipated that Clapper Rails will be present in all restored areas of Bair Island once appropriate habitat becomes established. Densities should reach levels comparable to those of known Clapper Rail populations in other marshes on San Francisco Bay (0.33 rails/hectare during the breeding season; after H. T. Harvey and Associates 1990). We anticipate that these levels would be achieved within 20 years of the establishment of appropriate habitat.
Salt Marsh Harvest Mouse	It is anticipated that salt marsh harvest mice will be present in all restored areas of Bair Island once appropriate habitat becomes established. CPUE is expected to exceed 3% within 20 years of the establishment of appropriate habitat.

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