ATTACHMENT C

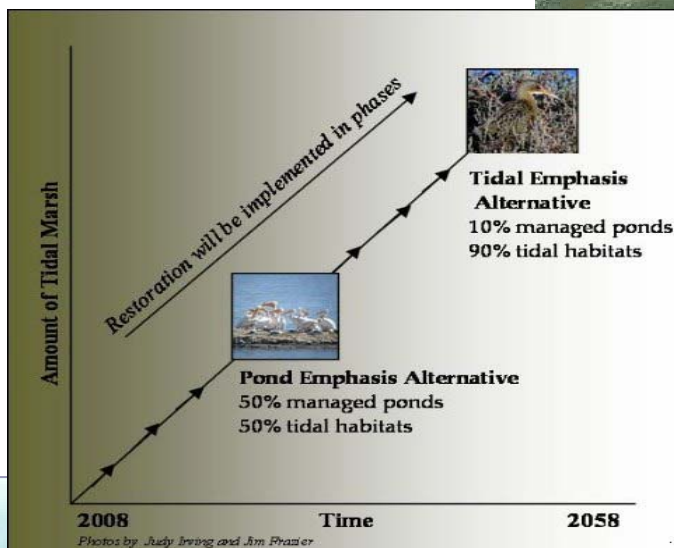
Waste Discharge Requirements and Water Quality Certification for the South Bay Salt Pond Restoration Project, Phase 2

Adaptive Management Plan and March 2018 Addendum on Habitat Transition Zones

ADAPTIVE MANAGEMENT PLAN

SOUTH BAY SALT POND RESTORATION PROJECT

ADAPTIVE MANAGEMENT PLAN



November 14, 2007
Science Team Report for the South Bay Salt Pond Restoration Project

Lead Author: Lynne Trulio
With Assistance from: Deborah Clark, Steve Ritchie, Amy Hutzel, and the Science Team

SOUTH BAY SALT POND RESTORATION PROJECT
ADMINISTRATIVE DRAFT ADAPTIVE MANAGEMENT PLAN

Table of Contents

SOUTH BAY SALT POND RESTORATION PROJECT
SCIENCE TEAM MEMBERS

Lynne Trulio, Lead Scientist	**San Jose State University**
John Callaway	**University of San Francisco**
Joshua Collins	**San Francisco Estuary Institute**
Edward Gross	**Environmental Consultant**
Bruce Herbold	**US Environmental Protection Agency**
Michael Josselyn	**WRA, Inc.**
Frederic Nichols	**US Geological Survey (ret.)**
Gillian O'Doherty	**NOAA Restoration Center**
David Schoellhamer	**US Geological Survey**
Cheryl Strong	**San Francisco Bay Bird Observatory (now with USFWS)**
Danielle LeFer	**San Francisco Bay Bird Observatory**
Lois Takahashi	**University of California, Los Angeles**
John Takekawa	**US Geological Survey**
Dilip Trivedi	**Moffat and Nichol**
Nils Warnock	**PRBO Conservation Science**

Executive Summary

This Adaptive Management Plan (AMP) is integral to the South Bay Salt Pond Restoration Project and is designed to help to guide the planning and implementation of each Project phase. Adaptive management provides a directed approach to achieving the Project Objectives through learning from restoration and management actions—actions for which many scientific and social uncertainties exist. The AMP lays out the background for adaptive management in Part 1, including the importance of adaptive management in the Project and how adaptive management will direct this long-term effort toward achieving the Project Objectives. Part 2 describes the foundations for adaptive management developed during the planning process, especially the key uncertainties, monitoring, applied studies, and modeling. The scientific approach to generating information and its use in decision-making for the long-term Project as well as the Phase 1 actions is described in Part 3. Part 4 discusses the institutional structures and processes for undertaking adaptive management. This AMP provides direction for the Project, especially Phase 1, based on the best current information. However, the Plan itself is designed to be adaptive and, therefore, many elements including the key uncertainties, applied studies, and the institutional structure may change and evolve over time.

In March 2003, state and federal agencies acquired 15,100 acres (>6100 hectares) of solar evaporation salt ponds in South San Francisco Bay from Cargill, Inc. These former salt ponds became the South Bay Salt Pond Restoration Project (the Project), which is managed collaboratively by the California State Coastal Conservancy (SCC), the U.S. Fish and Wildlife Service (FWS), and the California Department of Fish and Game (DFG). The Project is composed of three complexes; FWS owns and manages the Alviso and Ravenswood pond complexes and DFG owns and manages the Eden Landing pond complex. In 2003, the FWS and DFG began implementing the Initial Stewardship Plan (ISP), a management strategy to decouple the ponds from salt-making and prepare the ponds for restoration under the Project. From 2003-2007, the Project undertook a comprehensive planning process, in which the Project participants: 1. developed the Project's Objectives; 2. developed the scientific foundation; 3. engaged the public; 3. coordinated with the Army Corps of Engineers (ACOE) on the South San Francisco Bay Shoreline Study, a closely-related multi-objective study that includes the Project area; and 5. produced an EIS/R that evaluates the Project, as a whole, for 50 years as well as the Phase 1 actions, which are the first actions the Project Managers will implement as part of the 50-year program. The adaptive management approach described in this AMP is integrated into the *South Bay Salt Pond Restoration Project EIS/R*.

The overarching mission of the Project is the restoration and enhancement of wetlands in the South San Francisco Bay while providing for flood management and wildlife-oriented public access and recreation. The six Project Objectives (Table 1, see page 3), based on this mission, are central to Project planning and implementation. While much is known about the South Bay ecosystem, the Project participants identified eight key uncertainties that could make meeting the Project Objectives difficult. These uncertainties included sediment dynamics, bird response to changing habitats, non-avian species responses, mercury issues, invasive and non-native species, water quality, public access and wildlife, and social dynamics. The overarching uncertainty of global climate change is incorporated, defacto, into each of the specific key uncertainties.

The Project participants developed a number of visions for what the restored ecosystem could look like in 50 years. In particular, the EIS/R for the Project evaluated three alternatives: "No Project" in which ISP management continues for 50 years, a 50% tidal:50% managed pond

alternative in which approximately 50% of the Project Area is returned to tidal action and 50% is managed as ponded habitat, and 90% tidal:10% managed pond. While NEPA may require the Project Managers to identify a "preferred alternative", the Project participants agree that, due to the many uncertainties, the mix of habitats that will optimally meet the Project Objectives—including the amount of tidal restoration and its location--cannot be predicted at this time. Given this, the Project will implement restoration and management in phases and will use adaptive management as the process for determining how far the system can move toward full tidal action and associated tidal habitats, while still meeting the Project Objectives.

For this Project to succeed, no phase can proceed without including adaptive management as an element of the design and implementation. The Adaptive Management Staircase in Figure 2 (see page 8) is a conceptual view of this process. Adaptive management will provide the information needed to determine how far to proceed along the staircase and at what pace. Implicit in the staircase and the Project's core mission is that the Project will continue to add tidal habitat to the system, so long as the other Project Objectives are met. Also implicit is the possibility, although unlikely, that the Project might stop adding tidal habitat before 50% of the Project Area is returned to tidal action, if substantial unanticipated problems are identified. However, taking that action would require a new NEPA/CEQA evaluation and reconsideration by all regulatory agencies.

The AMP describes how providing public access, one of the goals of the Project, is also subject to adaptive management. The Adaptive Management Approach for Recreation and Public Access (Figure 3, page 9) shows that the suite of public access features described in Phase 1 is the minimum level of public access the Project will provide. Whether additional recreation and access features are provided in the future will be determined through a process that weighs both effects of access on target species and public demand for particular features.

During the planning stage, the Project moved forward with monitoring, applied studies, and model development. Monitoring during Project planning began in 2003 and characterized baseline conditions in all 54 ponds as well as the associated sloughs, and, to some extent, the South Bay before and after ISP implementation. This program also included compliance monitoring, specifically to track water quality conditions before and after culverts connecting ponds to the Bay were opened for ISP operation. Applied studies were initiated during planning, including a research effort to establish baseline levels of mercury in indicator (sentinel) species, a study of the physical and vegetation changes in response to restored tidal actions at the Island Ponds, and studies of bird use of managed and unmanaged ponds. In addition, the Project developed two large-scale models to predict physical and biological changes in response to management, and tapped a team of modelers to begin developing a detailed predictive, landscape-scale model.

Adaptive management of the Project is based on restoration targets, monitoring, applied studies, and modeling that will be used to generate the science-based information managers will need for decision-making. Adaptive management begins with clear, measurable restoration targets that link directly to the Project Objectives. Appendix 3 lists 28 restoration targets for the Project, which should be monitored to determine if more tidal habitat will be restored, i.e., whether the Project will continue along the adaptive management staircase. Monitoring, using appropriate parameters, allows Project Managers to assess progress toward Project Objectives. The Project participants identified the most essential parameters and some potential methods for collecting the needed data. The monitoring parameters in Appendix 3 are all expected to be measured beginning with Phase 1. Applied studies are listed for each restoration target and, during Phase 1, they will provide data to reduce uncertainties related to achieving the Project Objectives. Each restoration target has a management trigger for action if the system is not performing well. For each management trigger there is a list of potential actions the Project Managers might take if a management trigger is reached.

Both simple and complex numerical models will be employed throughout the adaptive management process to integrate knowledge gained from monitoring and applied studies, allow improved interpretation and extrapolation of observed trends, test and refine hypotheses, and aid in identification of key uncertainties. While individual applied studies may contain some modeling aspects, the Project has need of an integrated model that simulates interactions among physical and biological processes. A successful model will integrate new information as it becomes available and will allow Project Managers to evaluate movement along the adaptive management staircase.

Phase 1 of the Project will be implemented beginning in 2008 and actions, including restoring tidal action to some ponds, managing other ponds, and integrating public access, are planned for each of the three pond complexes. In Phase 1, specific applied studies are coordinated with each restoration and management action and are designed to produce information to help manage the current Phase as well as plan up-coming phases of restoration. Studies in Phase 1 focus on bird response to changing habitats, mercury methylation, public access and wildlife interactions, and pond management effects on the Bay.

The Project will need an effective institutional structure to achieve these four basic adaptive management functions:

1. Generate and synthesize data from monitoring to track restoration progress and from applied studies and modeling to reduce key uncertainties;
2. Convert the synthesized data into effective short- and long-term management decisions;
3. Involve the public in decision-making and make management decisions transparent; and
4. Store and organize Project information for use by the decision-makers and the public.

The organizational structure that will be used to carry out these functions includes the Project Management Team (PMT), which is responsible for decision-making and taking action on those decisions, the Science Program, which will generate and interpret data, the Information Management Staff, which will organize, store and disseminate Project information, and the Stakeholder Forum plus Local Working Groups, which will provide perspectives from the public. The PMT will make decisions on what monitoring, applied studies, and modeling to fund; actions needed to modify current phases; and the design of future phases. In addition to decision-making, the PMT also has important fund-raising and public outreach functions. Regulatory and funding entities will be involved in the Project as members of the PMT, when appropriate.

The Science Program will be run by two science managers, who will be members of the PMT and will set the direction for and oversee the work of the Science Program. It is anticipated that an array of contractors will do the work required for the Science Program, including collecting and analyzing monitoring data, conducting applied studies, providing reports that analyze and synthesize monitoring and applied studies results, and peer-reviewing Program products and the Program itself. The science managers will use the information generated by the contractors to revise and prioritize monitoring and applied studies and to make recommendations to the full PMT on management actions for current phases and the design of future phases.

Public involvement as an especially important component of successful adaptive management. The public will have multiple avenues to learn about Project activities and provide input to the Project Managers, including through the website as well as Stakeholder Forum and Local Work Group meetings. Collaborative learning among scientists, managers, and the public, will allow for public comment and input on the decision-making process and ensure transparency through Project reporting.

Project participants will operate using processes that integrate their activities on a yearly and more frequent basis. The Project will use processes that coordinate Project participants for effective decision-making and restoration implementation. As with other aspects of the Project, the institutional structures and processes are designed to be flexible, allowing them to evolve to achieve effective adaptive management.

All Project reports mentioned in this document are available through the California State Coastal Conservancy, California Department of Fish and Game, Don Edwards San Francisco Bay National Wildlife Refuge or the Project's website (http://www.southbayrestoration.org).

PART 1. INTRODUCTION: Rationale for Adaptive Management

A. Purpose

This Adaptive Management Plan (AMP) is an integral part the South Bay Salt Pond Restoration Project implementation and provides a strategy for achieving the Project Objectives. Adaptive management provides a guided approach to learning from restoration and management actions—actions for which many scientific and social uncertainties exist. In Part 1, the AMP gives the rationale for adaptive management of the Project. Part 2 describes the monitoring, applied studies, and modeling conducted during planning, which laid the foundation for adaptive management of the Project. This work was used to develop a data collection approach based on restoration targets, monitoring, applied studies, and management targets, described in Part 3, that will provide data for management responses. Part 4 describes the institutional structures and processes by which Project Managers, scientists, and stakeholders will work together for effective adaptive management decision-making. This AMP provides direction for the Project, especially in Phase 1, based on the best current information. However, the Plan itself is designed to be adaptive and elements such as the key uncertainties, applied studies, and the institutional structure may change and evolve over time.

B. The Role of Adaptive Management

Project Background. In March 2003, state and federal agencies acquired 15,100 acres (>6100 hectares) of solar evaporation salt ponds in South San Francisco Bay from Cargill, Inc. This acquisition provides the opportunity to restore wetlands on a scale unprecedented on the west coast of North America. The South Bay Salt Pond Restoration Project (the Project) is managed collaboratively by the U.S. Fish and Wildlife Service (FWS), the California Department of Fish and Game (DFG), and the California State Coastal Conservancy (SCC). The overarching goal of the Project is the restoration and management of wetlands in the South San Francisco Bay while providing for flood management and wildlife-oriented public access and recreation. The Project Management Team (PMT) and the Stakeholders developed six Project Objectives, based on this goal (Table 1).

The Project Area consists of 54 ponds ranging from 30 to 680 acres in size in three distinct pond complexes bordering South San Francisco Bay: the Alviso complex (7,997 acres in 25 ponds), the Eden Landing complex (5,450 acres in 22 ponds), and the Ravenswood complex (1,618 acres in 7 ponds) (Figure 1). The entire Project Area is surrounded by the highly urbanized landscape of the South Bay, also known as Silicon Valley. In 2005, according to the U.S. Census Bureau, over 3.8 million people lived in San Mateo, Santa Clara, and Alameda Counties (see http://quickfacts.census.gov/qfd/states/06000.html), the counties that border the three pond complexes. This urban landscape brings a significant human dimension to the Project. Project Objectives that focus on flood management, public access, mosquito control, and infrastructure protection attest to the importance of social factors in the Project.

The pond complexes consist primarily of former wetlands that were diked off from the Bay as early as the 1860s (Siegel and Bachand 2002). Creation of the levees, extensive urbanization, and other actions in the Project region had large effects on the ecosystem of the South San Francisco Bay (south of the San Bruno Shoal) including:

- the loss of at least 85% of historic tidal wetlands;
- changes in sediment dynamics;
- changes in freshwater flows;

- introduction of pollutants, especially mercury;
- changes in species composition and distribution, and
- significant population changes for a number of key species.

The restoration of substantial tidal habitat in the South Bay to reduce or reverse these impacts has long been a goal of the public and agencies (Habitat Goals 2000). However, complete restoration of tidal habitat to historic acreages would eliminate the salt ponds, which are now used for foraging, roosting and nesting by a wide variety of resident and migratory bird species. To maintain these species' presence in the South Bay, restoration and management of the Project Area must balance tidal habitat restoration with preservation of current habitat uses.

As a condition of the purchase, Cargill, Inc. was responsible for reducing pond salinity to the "transfer level", a condition set by the Regional Water Quality Control Board (RWQCB). Cargill, Inc. transferred the Eden Landing and Alviso ponds (except Ponds A22 and A23, which had not yet met the salinity transfer standard) to the DFG and FWS, respectively, between 2004 and 2005. Upon transfer, the agencies began to manage the ponds under a strategy called the Initial Stewardship Plan (ISP). The ISP is designed to control water salinities and maintain the ponds as independent systems that no longer make salt. In other words, the ISP decouples the ponds from salt making. ISP management produces low to moderate salinity ponds prepared for restoration or other management action as determined by the Project. Pond management under the ISP is described in the *South Bay Salt Ponds Initial Stewardship Plan* (Life Science 2003a, b). As a result of ISP management, pond conditions, especially salinity, have changed since the purchase. These changes have been monitored by the USGS, whose monitoring program is summarized in Part 2.

Much is known about the South Bay ecosystem (Goals Project 1999, 2000). On the landscape level, the EcoAtlas Baylands Maps provide excellent historical information on the extent, configuration and bathymetry of South Bay habitats in the 1800s (SFEI, 1998) and today (Collins and Grossinger, 2005). Current pollutant levels are under study (Davis, 2005) and the USGS has collected 30 years of data on the water quality, phytoplankton community, and pollutant levels in the South Bay (www.sfbay.wr.usgs.gov/access/wqdata/index.html). On the habitat scale, researchers have collected significant data on the evolution of restoring tidal habitat (Orr, et al., 2003), sediment dynamics (Schoellhamer et al., 2005), hydrodynamics, and tidal habitat community composition (Josselyn, 1983; PWA and Faber, 2004). Many species have received research attention, including the endangered California clapper rail (*Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris*), as well as invasive and non-native species (Josselyn, et al. 2005). The FWS has good data sets on winter waterfowl abundances and Point Reyes Bird Observatory (PRBO) has documented shorebird use of salt ponds and other South Bay habitats (Warnock, et al., 2002).

Despite the information available, a number of uncertainties and knowledge gaps exist that could inhibit the Project's potential to reach its Objectives. Monitoring and applied studies conducted during the Project's planning stage provided data on some of the uncertainties. However, all the uncertainties cannot be resolved before restoration starts. In fact, many data gaps can only be addressed by implementing restoration actions and learning from the results. Given this, the Project participants agreed that restoration and management should be implemented in phases and use adaptive management as the process for determining how far the system can move toward full tidal action and associated tidal habitats, while still meeting the Project Objectives.

Rationale for Adaptive Management. The process of learning by doing and then using the results to improve management actions is called *adaptive management* (Walters and Holling, 1990) and this process is a critical component of South Bay Salt Pond Restoration Project implementation. For this Project to meet its Objectives (Table 1), no phase can proceed without including adaptive management as a design and implementation element. Adaptive management is essential to keeping the Project on track toward its Objectives and is the primary tool identified in the *South Bay Salt Pond Restoration Project EIS/R* (2007) for avoiding significant impacts from the Project. The information produced through adaptive management will permit effective changes to current phases and assist in the design of future phases. If information is not collected and applied to management decisions, aspects of the Project will fail or *appear* to fail. Monitoring and applied study information will inform Project Managers as to whether the Project is meeting its Objectives and if not, whether problems are due to the Project or to forces beyond the Project's control. Without adaptive management, Project Managers will not understand the restored system nor will they be able to explain their management actions to the public. Ignorance of the ecosystem may jeopardize public support and funding for future phases and may result in significant negative impacts to the South Bay system and beyond.

Restoration practitioners have found that, because knowledge of natural and social systems is incomplete, systems will respond in unexpected ways. Surprises are also inherent in restoration because nature is variable and unpredictable, especially at large spatial scales and over long time frames. Adaptive management allows managers to prepare for and respond to novel events, from unexpected changes in dissolved oxygen levels to vandalism. When and where such events occur may not be predictable, but part of the adaptive approach is to anticipate the range of events and system responses that might occur and develop a process for dealing with them if they do happen. Monitoring and applied studies can help to prevent unintended consequences of the Project or, when they occur, can help to minimize any negative impacts and address them before they become substantial. Adaptive management allows the Project to move forward in light of regulatory requirements (NEPA, CEQA, FESA) by providing a process for preventing significant negative environmental impacts, to the greatest extent feasible.

This Project has multiple objectives and there may be trade-offs or costs as well as benefits. For example, the planning for this Project balanced the ecological benefits of tidal habitat restoration with the reduction of benefits that the salt ponds provide to some species. The Project also balances other goals such as amounts and locations of tidal restoration with required flood protection and public access with wildlife protection. Monitoring, applied studies, and modeling will help Project Managers understand the trade-offs and their social implications in order to make informed decisions.

TABLE 1. South Bay Salt Pond Restoration Project Objectives

Objective 1. Create, restore, or enhance habitats of sufficient size, function, and appropriate structure to:

A. Promote restoration of native special-status plants and animals that depend on South San Francisco Bay habitat for all or part of their life cycles.
B. Maintain current migratory bird species that utilize existing salt ponds and associated structures such as levees.

C. Support increased abundance and diversity of native species in various South San Francisco Bay aquatic and terrestrial ecosystem components, including plants, invertebrates, fish, mammals, birds, reptiles and amphibians.

Objective 2. Maintain or improve existing levels of flood protection in the South Bay area.

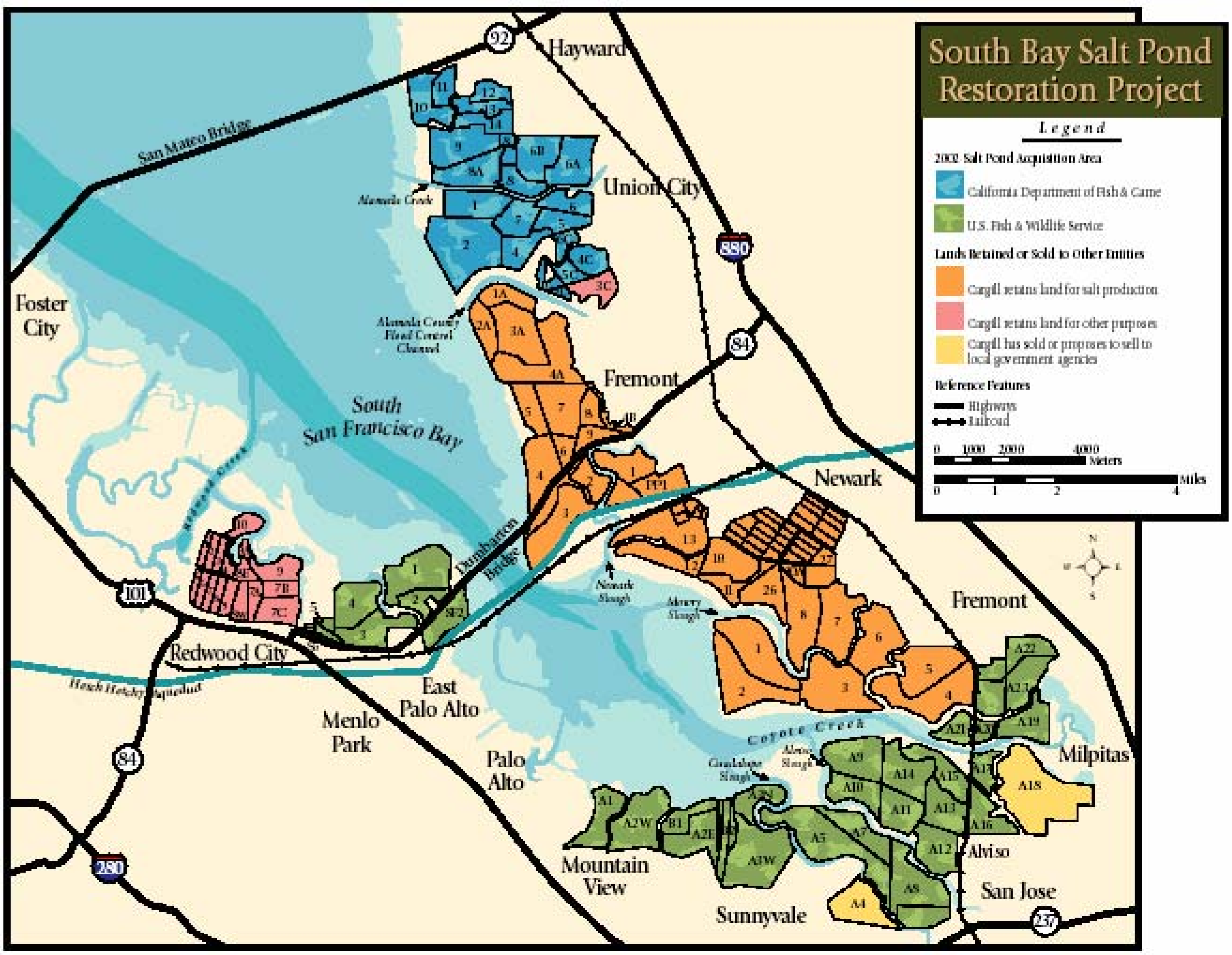
Objective 3. Provide public access opportunities compatible with wildlife and habitat goals.

Objective 4. Protect or improve existing levels of water and sediment quality in the South Bay and take into account ecological risks caused by restoration.

Objective 5. Implement design and management measures to maintain or improve current levels of vector management, control predation on special status species and manage the spread of non-native invasive species.

Objective 6. Protect the services provided by existing infrastructure (e.g. power lines).

FIGURE 1. The South Bay Salt Pond Restoration Project Area.
Blue ponds are the Eden Landing complex owned by the DFG; green ponds from Mountain View to Fremont are the Alviso Complex and those in Menlo Park are the Ravenswood complex, all owned by FWS. Cargill, Inc. retains ownership of the pink ponds. The orange ponds are mostly owned by the FWS, but Cargill continues to make salt there under an easement agreement. Yellow ponds are in the ownership of local government agencies.



C. Adaptive Management Defined

Adaptive management for natural resources was first described by Holling (1978). While there are many current definitions of adaptive management, one of the most applicable to this Project comes from Jacobson (2003) who states, "Adaptive management is a cyclic, learning-oriented approach to the management of complex environmental systems that are characterized by high levels of uncertainty about system processes and the potential ecological, social and economic impacts of different management options. As a generic approach, adaptive management is characterized by management that monitors the results of policies and/or management actions, and integrates this new learning, adapting policy and management actions as necessary."

In an adaptive management approach, resource management and restoration policies are viewed as scientific experiments. This concept is important because the environmental outcomes of management policies are often uncertain. Adaptive management encourages an ecosystem–level approach to resource management and encourages close collaboration among scientists, managers, and other stakeholders on key policy decisions (Jacobson 2003). To be effective, decision-making processes must be flexible and designed to be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood.

Adaptive management is a "formal process for continually improving management policies and practices by learning from their outcomes" (Taylor et al. 1997) and it incorporates natural variability in evaluating the results of management actions. Effective adaptive management is not trial and error, which typically reflects an incomplete understanding of critical components of the system. It does not focus solely on tracking and reacting to the fast, immediate variables; this leads to perpetual reactive, crisis management. For fundamental change, adaptive management monitoring includes slow, driving variables. Light and Blann (2001) explain this approach by stating that, "adaptive management is a planned approach to reliably learn why policies (or critical components of policies) succeed or fail". Restoration fails when managers do not learn from actions and policies and, ultimately, miss restoration goals.

This Project will occur in phases over an expected 50-year implementation horizon. This Project's adaptive management approach will allow Project Managers to learn from their actions and will achieve these four functions:

1. Generate science-based information for managers;
2. Convert information into effective management decisions;
3. Involve the public to help provide management direction; and
4. Store and organize information for use by the decision-makers and the public.

To summarize the role of adaptive management in ecosystem restoration projects, the National Research Council (2003) has said, "The learning process that will guide the 'adaptive implementation' of the Restoration Plan will depend on a research strategy that effectively combines monitoring, modeling, and experimental research with a high level of attention to information management, data synthesis and periodic re-synthesis of information throughout the implementation and operation of the Restoration Plan." The National Research Council (2003) also notes that, "As with any long-term environmental project, but especially one committed to an adaptive approach, learning depends on the continuity of adequate funding." While this AMP does not specifically discuss sources of funding or funding mechanisms, the Project participants recognize this is a critical issue for the Project. Securing adequate, constant, long-term funding will be a primary activity of the Project Management Team throughout the life of the Project and its adaptive management.

D. Visions of South Bay Ecosystem Restoration

The Project's geographic scale, encompassing most of the "baylands" and associated species within the South Bay as well as the interconnectedness of all the components, makes this an ecosystem restoration project. An ecosystem is composed of interacting elements of the physical and biological world that produce large-scale processes. Carbon uptake and loss, energy exchange, nutrient cycling and the water balance are typical processes used to distinguish one ecosystem from another (Woodward 1994). Ecosystems have characteristic disturbance regimes, microclimates, successional processes, and species diversity and interactions that occur over the majority of the system (Woodward 1994). To promote a healthy ecosystem and to restore maximum ecological diversity, adaptive management information for the Project must include the entire South Bay ecosystem, the Bay itself, and factors beyond the Bay that are significant influences on South Bay conditions.

Ecosystem restoration is complex and scientific understanding of ecological systems is insufficient to the task of restoring fully-functional systems. There are major information gaps and poor predictive capabilities on long-term and large spatial scales. Given our incomplete knowledge, a basic goal of restoration is to manipulate the system as little as possible and allow natural processes to restore ecological structures and functions, to the greatest extent feasible (National Research Council, 1992). Allowing nature to do the work is often the most successful approach to restoration and in many cases requires less management and reduces project costs. However, the South Bay is a highly altered system in an urban setting; some Project Objectives may be reachable only through constant management. Adaptive management will be used to determine the minimum amount of human intervention needed. In addition, restoring sustainable habitats for rare and indicator species may require intervention that focuses on particular species, habitats, or habitat components. While species-specific management may be necessary, it should not replace the Project's ecosystem focus.

The Project participants conceived a range of visions for the restored ecosystem in 2050. Based on Project input, the Consultant Team evaluated a "No Project" scenario and two Project alternatives—50% tidal habitat:50% managed pond and 90% tidal habitat:10% managed pond—in the *South Bay Salt Pond Restoration Project EIS/R* (2007) for the NEPA/CEQA process (Figure 2). While NEPA may require the Project Managers to identify a "preferred alternative", the Project participants realize that, due to many uncertainties, the mix of habitats that will optimally meet the Project Objectives—including the amount of tidal restoration and its location--cannot be predicted at this time. Specifically, the Project's Science Team identified eight key uncertainties relative to the Project Objectives, which include sediment dynamics, water quality, bird response to changing habitats, mercury methylation, invasive and nuisance species issues, effects on non-avian species, public access and wildlife interactions and social dynamics (see Part 2, Section B). Given these uncertainties, the Project will use adaptive management as the process for determining how far the system can move toward restoring full tidal action and tidal habitats, while still meeting the Project Objectives. The visions for the 50-year landscape are arranged in Figure 2 along a gradient from the landscape with the most managed pond and least tidal habitat (Phase 1) to the system with the most tidal habitat.

The *South Bay Salt Pond Restoration Project EIS/R* (2007) describes the "No Project" alternative as one in which restoration is not implemented but, rather, the Project area is managed indefinitely under the ISP. Under this scenario, ponds would continue to be managed as they are under the ISP and the agencies would maintain critical levees for flood protection.

Other levees would fail, allowing some tidal habitat restoration. Public access features would not be implemented. They also analyzed a 50% tidal habitat:50% managed pond mix and a 90% tidal habitat:10% managed pond scenario. These two scenarios form the likely "bookends" for what the Project area would look like in 50 years. The EIS/R assumes that at least 50% of the Project area would be restored to tidal habitat, but recognizes that the final configuration at 50 years would be a tidal habitat/managed pond mix somewhere between 50:50 and 90:10, as depicted in Figure 2. The EIS/R used information from this AMP to describe how adaptive management will be used to determine the optimal mix of habitats and avoid significant environmental impacts and the AMP is included as an appendix to that document. In essence, the proposed 50-year program is an adaptive management approach to restoration.

In addition to habitat restoration, the EIS/R describes how the Project will meet the other two parts of its mission: preserving or improving on current levels of flood protection and providing high quality, wildlife-compatible public access. The flood protection strategy for the Project is integral to the restoration plan. It is a combination of three elements: 1) levees along the landward edges of ponds to prevent tidal flooding, 2) restoration of tidal habitats along sloughs to increase floodplain storage, and 3) restoration of tidal habitats along sloughs thereby increasing tidal exchange and slough scour for greater channel conveyance. For more detailed planning and implementation of restoration incorporating flood protection, the Project Managers are collaborating with the Army Corps of Engineers (Corps) on the South San Francisco Bay Shoreline Study. The Project Managers will work with the Corps to ensure flood protection is achieved, but adaptively managed as the Project progresses.

A program for high quality, diverse public access, including trails, overlooks, and interpretive features, will also be adaptively managed. Public access features are designed to meet wildlife compatibility requirements, based on current information. However, there is significant uncertainty about the effects of public access on sensitive species. Information from monitoring and applied studies will be used to adaptively manage public access based on: 1) public access effects on wildlife, and 2) public demand for access/recreation features. For example, wildlife managers currently assume that public access features, such as trails, will negatively affect California clapper rails and Western snowy plovers, which are listed species. Studies of trail effects on these species may confirm this suspicion, requiring protective measures; or data may refute this assumption, suggesting that agencies revisit the issue of public access adjacency to these species. Project Managers will also evaluate assumptions about what features the public wants and then adjust current and future Project actions to meet those desires, whenever possible. The Project's approach to adaptive management of public access is depicted in Figure 3, which shows that the public access features planned for the first phase of the Project are the minimum in public access the Project will provide. Whether additional recreation and access features are provided will be determined through a process that weighs both effects of access on target species and public demand for particular features.

Adaptive management will provide the information needed to determine how far to proceed along the tidal habitat staircase and at what pace; Project information may show that the Project should move more quickly or slowly along the staircase. Implicit in the adaptive management staircase and the Project's core mission is that the Project will continue to add tidal habitat to the system, so long as the other Project Objectives are achieved. It is also possible, although unlikely, that the Project Managers might stop adding tidal habitat before 50% of the Project area is returned to tidal action, if substantial problems are identified at that point. However, because the EIS/R evaluated the impacts of 50% tidal habitat as the minimum level of restoration, i.e. the lower "bookend", if Project Managers wish to restore less than that amount, they would need, at the very least, to revisit regulatory requirements with permitting agencies. For example, the FWS Endangered Species Office may undertake a jeopardy analysis for listed species.

In each Project phase, adaptive management will be most effective if Project Managers implement actions for which outcomes are most certain and include those actions that provide good opportunities to study uncertainties. In moving the Project along the adaptive management staircase (Figure 2), Project Managers should take care to avoid designing and implementing irreversible actions for which there is a moderate to high risk of not achieving Project Objectives, and they should avoid taking actions that preclude reaching more complete levels of tidal action. As Project Managers learn more about the system through adaptive management, more types of actions will become predictable and can be implemented.

FIGURE 2. Adaptive Management Staircase for Tidal Habitat Restoration
(MP=percent of managed ponded habitat; ISP=Initial Stewardship Plan)

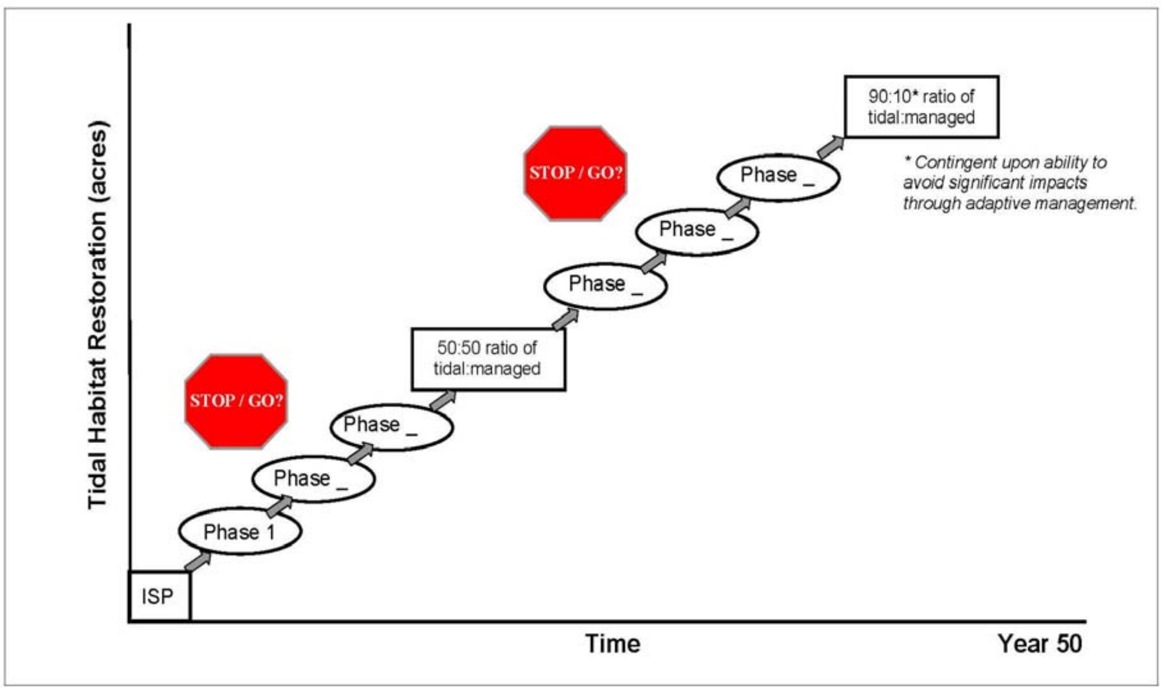
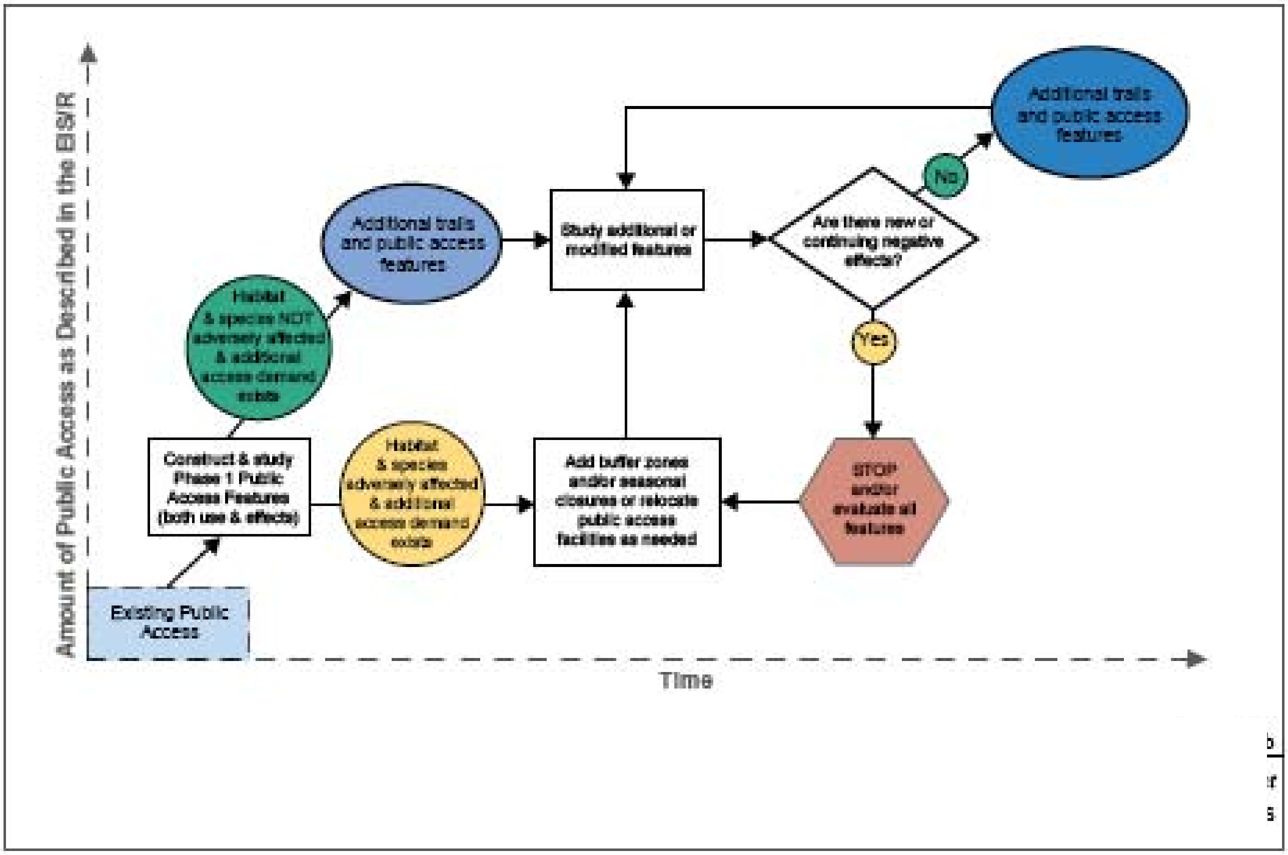


FIGURE 3. Adaptive Management Approach for Recreation and Public Access



PART 2. PLANNING: The Foundation for Adaptive Management

A. Key Uncertainties and Applied Studies

During the planning phase from 2003-2007, the Project participants worked together to lay the groundwork for adaptive management during Project implementation. The Science Team led the effort that developed the science foundation for the Project by writing a series of Science Syntheses (focused literature reviews), holding technical workshops on important Project issues, and identifying the Project's key uncertainties, which led to a list of applied studies for testing. The Project Management Team worked with USGS and the San Francisco Bay Bird Observatory (SFBBO) to develop a plan for baseline data collection that the USGS conducted for the Project. The Consultant Team developed significant amounts of information for the Project through its EIS/R research and, with review from some Science Team members, developed several large-scale predictive models. Given the uncertainties, the Project participants agreed that incorporating adaptive management into the Project was essential to success.

A primary task relevant to adaptive management was to determine where gaps in our knowledge about South Bay ecosystem functioning or restoration significantly hinder our ability to achieve the Project Objectives. The Science Team, with input from the other Project participants, identified the following list of key Project uncertainties:

- **Sediment dynamics**, especially the extent to which tidal habitat restoration might result in the loss of slough and Bay tidal mudflat habitat (links to Project Objective 1A and 1C).
- **Bird use of changing habitats**, especially the extent to which tidal habitat species can be recovered while maintaining the diversity and abundance of nesting and migratory waterbirds observed during pre-ISP conditions (links to Project Objective 1B).
- **Effects on non-avian species**, especially the extent to which restoration and management will affect fish and other critical species in the South Bay ecosystem (links to Project Objective 1C).
- **Mercury**, especially the extent to which Project restoration and management actions might result in an increase in bioavailable mercury in the food chain above pre-ISP levels (links to Project Objective 4).
- **Water quality**, especially the effects of pond management regimes on slough and Bay water quality and important species (links to Project Objective 4).
- **Invasive and nuisance species**, especially the invasive *Spartina* hybrids, red foxes, California gulls, and mosquitoes (links to Project Objective 5).
- **Public access and wildlife**, especially the extent to which various forms of public access and recreation can be integrated into the Project without significantly affecting wildlife (links to Project Objective 3).
- **Social dynamics**, especially the extent to which the local population in the South Bay will actively support the Restoration Project over time (links to all Project Objectives, but especially Project Objectives 2 and 3).

The Project's Science Syntheses (available from the managing agencies or on the Project website) provide more information on the connection between these uncertainties and the Project Objectives.

The Science Team then developed a list of the highest priority applied studies, to be researched through hypothesis testing and modeling, in order to reduce the eight key uncertainties. Table 2 lists the 21 applied studies questions and when research is expected to occur. Each of these questions will require multiple studies in order to develop adequate information for management. In addition, numerical modeling is essential to address questions and develop predictive power. Specifically, sediment dynamics questions, water quality, mercury transport, bird carrying capacity, and effects of human population dynamics all require modeling. Results from many of the applied studies and models are needed to proceed from Phase 1 into later phases. Appendix 1 describes the rationale for each most of the applied studies and gives likely hypotheses for testing or modeling, conceptual study designs, and management uses for the information. All applied studies research for this Project will undergo peer review an must employ well-designed, unbiased data collection and analysis methods, as accepted in their fields.

Several caveats about research are worth noting. First, some studies may require construction of features for isolating treatments or otherwise implementing the manipulation and may, in some cases, conflict with restoration goals (Walters, 1997). For example, providing tidal action into specific ponds to test mercury methylation may result in increased mercury in the system. Whenever possible, irreversible changes for study manipulations will be avoided. But, if they cannot, Project Managers will need to evaluate the trade-offs between the benefits the study provides and the costs to achieving a Project Objective. Second, although they are chosen to try to reduce unknowns and develop meaningful management information, some studies may not produce data that are immediately useful to the Project or may produce completely unexpected results. Project Managers will minimize these situations by regularly evaluating key uncertainties and *requiring that proposed studies link directly to management*. The Science Team during planning did an excellent job ??? of selecting the most critical uncertainties and studies.

It is absolutely critical, throughout the life of the Project, that the Project Managers and scientists continue to carefully select a targeted, short list of key applied studies for funding that are specifically linked to management needs and achieving the Project Objectives. Unless research needs are tightly defined, the Project can easily veer off in a direction of collecting large amounts of data that ultimately do little to help managers. This direction would be highly detrimental to the Project. Therefore, one of the most important on-going tasks of the science managers will be to tightly define the most critical applied studies and modeling efforts that provide the information managers need in a timely manner. The science managers will achieve this through regular review of the key uncertainties and applied studies, with direct input from the Project Managers.

During planning, the Project and other agencies initiated a number of applied studies to begin this component of adaptive management; they are listed in Table 3. Major study efforts included the research program developed by San Francisco Estuary Institute (SFEI), USGS, and the Santa Clara Valley Water District (SCVWD) to help establish baseline levels of mercury in indicator (sentinel) species and to assess whether restoring a managed pond, A8, to reversible muted tidal action will increase mercury levels in these species. The reversibility of this project will limit species' exposure. In addition, FWS and USGS undertook a multi-million dollar study of mercury levels in San Francisco Bay and Delta birds, funded through the CALFED process. This research included study of mercury levels in South Bay avocets, stilts, and terns. Another major research effort, this one funded by the Project, focused on the physical and vegetation changes at the Island Ponds, Ponds A19, A20, and A21, during the first year after they were breached. Research was initiated at these ponds just prior to breaching in March 2006. Other applied studies undertaken by PRBO Conservation Science (PRBO), San Francisco Bay Bird

Observatory (SFBBO), and San Jose State University (SJSU) focused on bird use of habitats and public access-wildlife interactions.

While each of the 21 applied studies is considered essential to reducing key uncertainties, studies should be sequenced in a way that takes advantage of ecosystem conditions as the Project progresses. Sequencing the studies ensures that critical path research is started when the timing is appropriate. From a funding standpoint, sequencing lists the studies that need to be funded immediately and those for which funding will not be needed until later. Appendix 2 gives the three-tiered approach and rationale for sequencing the studies that the Science Team identified during planning. Briefly, the three tiers are:

Sequence 1 includes studies to be implemented at the beginning of Phase 1 or before, either because they address a direct threat to our ability to achieve Project Objectives, because Phase 1 provides ideal conditions to study the question, or the findings are essential to implementing future actions. Studies focus on bird use of managed habitats, mercury methylation, pond management effects on the Bay, California gull impacts, public access and wildlife interactions, and assessing public support for the Project.

Sequence 2 includes studies to be initiated some time in Phase 1, but more fully in conjunction with future Project actions. Phase 1 conditions are not ideal for addressing these questions, but some data can begin to be collected in Phase 1. Studies focus on sediment dynamics in restored ponds and the Bay, *Spartina* and other invasive species, and boating effects on wildlife.

Sequence 3 includes studies to be initiated after Phase 1 actions have been implemented and habitat has evolved or data from Sequence 1 studies have been collected. Studies focus on tidal restoration effects on species, pond/panne habitat, costs/benefits of restoration on local communities, and effects of long-term population and demographic change.

TABLE 2. Key Scientific Uncertainties and Applied Studies

	Key Uncertainties, in italics, are followed by specific, high-priority Applied Study Questions (in bold) with a brief explanation of the importance of each question.	Where Studies are Planned
	Sediment Dynamics. Is there sufficient sediment available in the South Bay to support marsh development without causing unacceptable impacts to existing habitats?	
1	**Will sediment accretion in restored tidal areas be adequate to create and to support emergent tidal habitat ecosystems within the 50-yr projected time frame?** Sediment deposition has varied greatly over the last 150 years. Large-scale restoration occurring over decades will also affect sediment dynamics throughout the South Bay and regional study will be required to understand these changes.	Island Ponds, Phase 1 at A6 & E8A/9/8X
2	**Will sediment movement into restored tidal areas significantly reduce habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance in the South Bay?** Sediment accretion into the restored ponds is expected to reduce the amount of mudflat in the South Bay, but it is not known whether mudflat loss will be significant in terms of acreage or its effect on South Bay ecology. Such changes are expected to occur over decades.	Phase 1 at A6, A8 & E8A/9/8X
3	**Will restoration activities always result in a net decrease in flood hazard?** Increased tidal prism will scour slough channels within a relative short time frame (months to years) and reduce flood hazard. Changes in tidal elevations and prism in sloughs occurring over months to years may potentially increase flood hazard.	Phase 1 at A6 & E8A/9/8X
	Bird Use of Changing Habitats. Can the existing number and diversity of migratory and breeding shorebirds and waterfowl be supported in a changing (reduced salt pond) habitat area?	
4	**Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions?** Overall ecosystem changes and effects must be measured and compiled over decades to understand the overall implication of South Bay restoration on migratory birds. Some factors that could affect bird numbers are changes in disease and predation rates, food availability, and nest competition.	During and after Phase 1
5	**Will shallowly flooded ponds or ponds constructed with islands or furrows provide breeding habitat to support sustainable densities of snowy plovers while providing foraging and roosting habitat for migratory shorebirds?** Simple changes to existing pond management or simple habitat alteration may significantly benefit nesting snowy plovers while still providing nesting and foraging habitat for other species, but the extent of potential benefits is not known.	ISP at E6A, E6B, E8, & E16

Key Uncertainties, in italics, are followed by specific, high-priority Applied Study Questions (in bold) with a brief explanation of the importance of each question.		**Where Studies are Planned**
Bird Use of Changing Habitats. (continued)		
6	**Will ponds reconfigured and managed to provide target water and salinity levels significantly increase the prey base for, and pond use by waterfowl, shorebirds and phalaropes/grebes compared to existing ponds not managed in this manner?** Ponds managed as small-scale salt pond systems may provide enhanced benefits for wide range of birds. But, the extent to which they can improve the prey base and increase foraging shorebird densities in the short and long-term is not known.	Phase 1 at E12/13
7	**To what extent will the creation of large isolated islands in reconfigured ponds maintain numbers (and reproductive success) of terns and other nesting birds in the South Bay, while increasing densities of foraging birds over the long term compared to ponds not managed in this manner?** Changing salt pond island configurations may result in significant increases in nesting and foraging bird densities but to what extent is not known.	Phase 1 at A16 & SF2
8	**Will pond and panne habitats in restoring tidal habitats provide habitat for significant numbers of foraging and roosting shorebirds and waterfowl over the long term?** Naturally-maintained pond and panne habitat within marshes could potentially provide significant habitat for many species that currently use ponds. But, little is known about the extent of potential benefits to waterbird species on short or long timescales.	Phase 1 at E8A/9/8X
9	**How do California clapper rails and/or other key tidal habitat species respond to variations in tidal marsh habitat quality and what are the habitat factors contributing to that response?** Increased tidal habitat is expected to boost populations of California clapper rails and other key species, but the data on the conditions that produce high quality habitat for survival and reproduction are needed.	As appropriate habitat develops
Effects on Non-Avian Species. Can restoration actions be configured to maximize benefits to non-avian species both onsite and in adjacent waterways?		
10	**To what extent will increased tidal habitats increase survival, growth and reproduction of native species, especially fish and harbor seals?** The extent to which restoring tidal habitats will affect native species, including steelhead, harbor seals, native fish and oysters, is unknown. This question requires long-term study on local and regional scales relevant to the species examined.	During and after Phase 1

<u>Key Uncertainties</u>, in italics, are followed by specific, high-priority <u>Applied Study Questions</u> (in bold) with a <u>brief explanation</u> of the importance of each question.		**Where Studies are Planned**
<u>Mercury</u>. Will mercury be mobilized into the food web of the South Bay and beyond at a greater rate than prior to restoration?		
11	**Will tidal habitat restoration and associated channel scour increase MeHg levels in marsh and bay-associated sentinel species?** Restoration actions could increase the bioavailability of mercury in sediment and water. Bioavailable mercury becomes a problem when it leads to deleterious accumulation in wildlife and people. Sentinel species, such as some invertebrates, fish and birds, are a cost effective way to monitor this toxic pollutant.	ISP at A8 and Phase 1 at E8A/9/8X & A8
12	**Will pond management increase MeHg levels in ponds and pond-associated sentinel species?** Pond management could increase the bioavailability of mercury in sediment and water over pre-ISP conditions. Sentinel species, such as some invertebrates, fish and birds, are a cost effective way to monitor this pollutant.	Phase 1 as part of A8 study
<u>Water quality</u>: Will restoration adversely affect water quality and productivity?		
13	**What is the effect of a) pond management, including increased pond flows and associated managed pond effects, and b) increased tidal prism from tidal habitat restoration on water quality, phytoplankton and fish diversity and abundance, and food web dynamics in South Bay?** Pond management and resulting water discharges to the Bay have the potential to decrease slough and Bay water quality and affect Bay species, but little is known of the short or long-term effects of pond management on the South Bay ecosystem. Restoring tidal action to ponds will increase the tidal prism and tidal currents in South Bay. South Bay phytoplankton dynamics at the base of the food web are dependent on hydrodynamics and mixing.	Phase 1
<u>Invasive and Nuisance Species</u>. Can invasive and nuisance species such as <u>Spartina alterniflora</u> (or the invasive <u>Spartina</u> hybrid), corvids and the California gull and, if warranted, raptors such as the northern harrier, be controlled. I f not, how can the impacts of these species be reduced in future phases of the project?		
14	**Where not adequately eradicated, does invasive *Spartina* and hybrids significantly reduce aquatic species and shorebird uses?** The Invasive Spartina Project is a comprehensive program to control *Spartina alterniflora* hybrids to a level at which native species are not threatened. If this Project is not successful, this applied studies question would need investigation.	Depends on Invasive Spartina Project results
15	**Will California gulls, ravens, and crows adversely affect (through predation and encroachment on nesting areas) nesting birds in managed ponds?** Data indicate that a number of native predatory species are increasing in population and are negatively affecting native breeding birds, but the extent of the impacts are not known.	Phase 1 at A6, A16, & SF2

	<u>Key Uncertainties</u>, in italics, are followed by specific, high-priority <u>Applied Study Questions</u> (in bold) with a <u>brief explanation</u> of the importance of each question.	**Where Studies are Planned**
<u>Public Access and Wildlife</u>. Will trails and other public access features / activities have significant negative effects on wildlife species?		
16	**Will increases in boating access significantly affect birds, harbor seals or other target species on short or long timescales?** While there is a strong constituency for increased boating access, there is almost no information in the San Francisco Bay on the immediate or long-term effects of recreational boating on birds or other target species in different habitat types.	During and after Phase 1
17	**Will landside public access significantly affect birds or other target species on short or long timescales?** Information on the short and long-term effects of general and specific trail uses, such as dog walking, on birds and other key species in different habitat types (ponds, sloughs, tidal habitat) is mostly lacking, as is information on effective mitigation measures.	Phase 1 at E12/13, A16, & SF2
18	**Will public access features provide the recreation and access experiences visitors and the public want over short or long timescales?** The public's desire for recreational uses changes over time. Understanding and providing the opportunities people value, to the extent feasible, is essential for the Project engender stewardship and public support in the short and long-term.	Phase 1
<u>Social Dynamics</u>. How can the Project gain support from the public now and into the future?		
19	**Will voters, advocacy groups, elected officials, and government agencies support the project (especially in terms of funding) over the short timescale at the local and regional spatial scales?** While the Project does not seem to generate opposition and habitat restoration seems popular in the Bay Area, there are factors that may impede public and political support, such as competing funding initiatives and very local community concerns.	Phase 1
20	**What are the benefits and costs associated with the project sites and will they be shared equitably among communities, businesses, municipalities, and/or government agencies at local and regional scales?** Cities/municipal governments may worry about economic costs and benefits attributable to the Project that will spill over into jurisdictions, especially concentrated costs, but also benefits attributable to the Project. The project will also generate regional benefits (and perhaps costs).	During and after Phase 1
21	**Will impacts associated with population growth and development adjacent to the project sites and beyond be successfully managed over the long timescale at the regional scale?** Population growth, densification, and development in the South Bay and the region as a whole will affect the ability of adaptive management to reach the project objectives. There is some information on population growth, but little information on how the particular patterns of growth and development will affect the project sites.	During and after Phase 1

TABLE 3. Monitoring, Applied Studies, and Modeling during Project Planning

	Project or Study*	Funded By*	Funding Amount
	Monitoring Project		
1	Pond and Project Area Monitoring—USGS, J. Takekawa, D. Schoellhamer, B. Jaffe (2003-05)	Project	~$600K/year (2003-05) ~$350K/year (2005-06)
2	LIDAR Survey of South Bay--TerraPoint	Project	$178K
3	Bathymetric Survey of the South Bay--Sea Surveyor, Inc.	Project	$380K
4	Urban Levee Flood Management Requirements--Moffat and Nichol	Project	$300K
5	ISP Water Quality Monitoring--USGS, J. Takekawa	FWS and DFG	
6	ISP Mercury Monitoring—USGS, K. Miles (2005-06)	FWS and DFG	~$50K
	Applied Study		
1	Island Ponds initial physical and vegetation change—UC Berkeley, M. Stacey; USF, J. Callaway; SFSU, T. Parker *Applied Studies Question*: Will sediment accretion in restored tidal areas be adequate to create and to support emergent tidal habitat ecosystems within the 50-yr projected time frame?	Project	~$100,000
2	Water Quality Data QC and Compilation—USGS, J. Cloern *Applied Study Question*: What is the effect of a) pond management, including increased pond flows and associated managed pond effects, and b) increased tidal prism from tidal habitat restoration on water quality, phytoplankton and fish diversity and abundance, and food web dynamics in South Bay?	USGS	In-kind
3	Pond A8/South Bay Mercury Study--SFEI, USGS, SCVWD *Applied Study Questions*: * Will tidal habitat restoration and associated channel scour increase MeHg levels in marsh and bay-associated sentinel species? * Will pond management increase MeHg levels in ponds and pond-associated sentinel species?	SCVWD, FWS, SFF, SCC, RMP	$750,000
4	Bird Diversity and Abundance on Newark Ponds—SFBBO *Applied Study Question*: Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions?	SFF and FWS	$80K for 2 years

	Project or Study*	Funded By*	Funding Amount
5	Bird Use of Mature and Restored Marshes—PRBO *Applied Study Questions*: * Will pond and panne habitats in restored tidal habitats provide habitat for significant numbers of foraging and roosting shorebirds and waterfowl over the long term? * How do California clapper rails and/or other key tidal habitat species respond to variations in tidal marsh habitat quality and what are the habitat factors contributing to that response?	SFF	$60K for 2 years
6	Snowy Plover use of Managed Ponds; Harbor Seal Response to Watercraft; CA Gull Impacts to Nesting Birds—SJSU, L. Trulio *Applied Study Questions*: * Will shallowly flooded ponds or ponds constructed with islands or furrows provide breeding habitat to support sustainable densities of snowy plovers while providing foraging and roosting habitat for migratory shorebirds? * Will increases in boating access significantly affect birds, harbor seals or other target species on short or long timescales? * Will California gulls, ravens, and crows adversely affect (through predation and encroachment) nesting birds in managed ponds?	SJSU	In-kind
7	Hg in SF Bay-Delta Birds: Trophic pathways, bioaccumulations, and ecotoxicological risk to avian reproduction—USGS, J. Ackerman; FWS personnel *Applied Study Questions*: * Will tidal habitat restoration and associated channel scour increase MeHg levels in marsh and bay-associated sentinel species? * Will pond management increase MeHg levels in ponds and pond-associated sentinel species?	CALFED	$2 million total (not all in South Bay)
8	Native Oyster Establishment Study—Save the Bay, M. Latta *Applied Study Question*: Will increased tidal habitats increase survival, growth and reproduction of native species, especially fish and harbor seals?	Save the Bay, NOAA, SJSU	
	Modeling Project		
1	Small and Large-Scale 3-D Integrative model	SCC	Approximately $3 million
2	South Bay Geomorphic Assessment—PWA	Project	
3	Habitat Conversion Model—PRBO	Project	$215K
4	NOAA/URS Fish Model	NOAA Fisheries	In-kind

* Acronyms: FWS=US Fish and Wildlife Service; DFG=California Department of Fish and Game; SCVWD=Santa Clara Valley Water District; SFF=San Francisco Foundation; SCC=Coastal Conservancy; SJSU=San Jose State University

B. Baseline Monitoring

Data Collection. Monitoring during Project planning began in 2003 to characterize conditions in the ponds, sloughs, and, to some extent, the Bay before and after ISP implementation (Table 3). This extensive monitoring effort provided both baseline data and a foundation for long-term, adaptive management monitoring. Reports are available through the California State Coastal Conservancy, California Department of Fish and Game, Don Edwards National Wildlife Refuge, or the Project's website (http://www.southbayrestoration.org).

USGS was contracted to do intensive and wide-spread baseline monitoring. USGS staff collected data on all 54 ponds and the data set from 2003-2005 included these parameters:

- bathymetry (depth and topography) of the ponds, sloughs, and South Bay;
- monthly bird abundance and diversity in the ponds;
- water salinity, pH, temperature, turbidity, DO, nitrogen (NH_4-N and NO_3-N), total and soluable phosphorus, and sulfur concentrations;
- chlorophyll 'a' (primary productivity);
- sediment salt content, particle size, and bulk density;
- invertebrate composition in sediment cores and from the water column (collected once);
- monthly fish abundance and diversity, and habitat characteristics at capture locations;
- Hg and MeHg levels in sediment in the Alviso and Eden Landing ponds, MeHg levels in invertebrates; bacteria community analysis at high and low MeHg production sites in Eden Landing ponds.

In 2005-2006, the USGS continued data collection at the 54 ponds with these exceptions:

1. No collection of benthic organisms;
2. No fish collection in ponds;
3. Bi-monthly bird surveys on all ponds, instead of monthly; and
4. Bi-monthly bird surveys on tidal flats in the Bay and sloughs were added.

In addition to pond bathymetry, bathymetry of the tidal flats and topography of levees was measured by LiDAR; subtidal bathymetry with some sediment surface classification was collected by Sea Surveyor, Inc. In fall 2005, SFBBO began a two-year study of bird use of the Refuge ponds in the South Bay that are still operated by Cargill for salt production. These data add to the baseline information on bird use of South Bay habitats.

Little data on pond conditions prior to the acquisition in 2003 were collected, although USGS collected data from 2001-2003 on selected Alviso salt ponds regarding water quality, nutrient concentrations, the structure of pelagic and benthic invertebrate communities, and waterbird abundance and distribution. Other information on South Bay conditions prior to the acquisition have been collected over the years by many different groups and agencies. There are many USGS reports (including those from 30-year monitoring programs), SFEI reports such as those for the Regional Monitoring Program and the EcoAtlas, agency monitoring programs (DFG South Bay fish monitoring), and graduate student theses. Some of these data were useful in planning and may be valuable in the future.

One source of multi-source data is the comprehensive catalog of water quality data sets compiled by the USGS (accurate through October 2006). South Bay Salt Pond Restoration Program Water Quality Data Inventory is an overview of the water quality information--chemical, physical, and biological—collected by many groups in and around South San Francisco Bay and the salt ponds. This Inventory is designed to help Project participants and other researchers find water quality data sets and ancillary environmental information from other groups working in the region (see http://www.southbayrestoration.org).

Pond Conditions. Data from the Project's monitoring efforts showed that pond conditions changed during the 2003 to 2005 monitoring period compared to conditions during Cargill's salt pond operation. During 2003 to 2004, Cargill reduced pond salinities to meet the transfer standard. In 2004, water control structures (gated culverts) were installed in Ponds A1 through A3W (Charleston Slough to Guadalupe Slough) in the Alviso complex and, in July 2004, the culverts were opened allowing Bay waters to flow into these ponds for the first time in many decades. Gated culverts were installed and opened to the Bay in 2004 in Ponds B2 and B10 at Eden Landing and in 2005 at Ponds A5 through A17 (Guadalupe Slough to Coyote Creek) in the Alviso complex. Then, in March 2006, the three Island Ponds, between Coyote Creek and Mud Slough, were opened to unrestricted tidal action. Thus, the monitoring that began in 2003 occurred when Cargill was reducing salinities and included approximately a year of data before ISP operation began in 2004.

The USGS summarized its data on water quality, water and sediment mercury levels, biotics, and bathymetry, for use during planning. Initial data showed some interesting findings. In the first migratory season after the ISP was implemented, shorebird numbers increased at both the Eden Landing and Alviso Complexes by at least 100% from pre-ISP conditions (Takekawa pers. comm.). FWS data for waterfowl showed similar increases in the Alviso complex (Morris pers. comm.). However, in the Eden Landing complex, water level draw-downs reduced habitat and bird use by piscivores, diving ducks, and grebes substantially from pre-ISP levels. Continued monitoring will determine whether these changes actually resulted from changing pond conditions as a result of the ISP or from inter-annual variation, and whether species responses will continue over time.

The USGS also conducted compliance monitoring, specifically to track water quality conditions before and after culverts were opened for ISP operation. One year of monitoring has shown that salinity, which Project Managers worried would not meet requirements set by the Regional Water Quality Control Board (RWQCB), has not been a problem. However, low dissolved oxygen (DO) levels, which were anticipated to a degree, have plagued a number of ponds during the summers of 2004 and 2005. These early findings show that management actions in the Project area are already causing changes in the system, some of which are not easily predictable and require study to fully understand.

C. Modeling During Planning

Models that integrate data and are able to predict system response to management actions will be invaluable to Project Managers as they deal with changing conditions and design future phases. During planning, several modeling approaches were developed to help predict changes to the system (Table 3). Philip Williams and Associates used the South Bay Geomorphic Assessment to predict large-scale habitat changes under various restoration scenarios. This general model used existing information on pond, slough and Bay bathymetry, sediment/hydrodynamics, sediment accretion rates, and a number of other factors to predict tidal habitat evolution and habitat acreages under different tidal habitat to pond ratios. Estimates of sea level rise, based on the predictions from the Intergovernmental Panel on Climate Change that were available during model development, were included in the South Bay Geomorphic Assessment to assess whether sediment accretion in restoring marshes would keep pace with sea-level rise due to global climate change. The results of this assessment were used in the EIS/R to evaluate the impacts of the “No Project”, 50% tidal:50% managed pond, and 90% tidal:10% managed pond alternatives. The Consultant Team also conducted hydrodynamic modeling, coastal flooding analyses and fluvial flooding analyses to further evaluate the three scenarios for the EIS/R.

A second model set, the Habitat Conversion Model, was developed by PRBO to predict bird population response to the restoration alternatives. Using the habitat change results predicted by the South Bay Geomorphic Assessment, PRBO used its model to estimate how bird populations currently using the South Bay might change in response to different tidal to pond ratios. These results were also used in the EIS/R to evaluate the impacts of different alternatives. The model will continue to be refined and used in the future as part of the monitoring analysis for migratory waterbirds.

Formal and informal reviews of these models by other scientists revealed limitations in their predictive power. The time line for Project planning did not allow further refinement of these models before implementation. Thus, model refinement and development will be part of long-term adaptive management. In particular, the Project is in need of modeling tools for predicting large-scale and long-term geomorphic and ecological changes to the system. While some tools do exist in the public domain, a concerted research effort is needed to identify and adapt an appropriate model to the South Bay system. For the long-term success of this Project, a 3-D model that integrates key physical parameters over small and large-scales and multiple timescales is needed to predict sediment dynamics, contaminant transport, salinity gradients and other factors in response to management actions and to external factors such as climate change. A research team associated with the Project developed a proposal for this type of model and the Project sought funding for it (Appendix 1). Research at the Island Ponds initiated during planning produced data and small-scale modeling that will be used as inputs into the larger model.

The uses of landscape-scale predictive models are varied:

1. To forecast the response of the system and parts of the system to different restoration and/or management actions, and thereby function as a design tool;

2. To predict certain types of conditions, such as low dissolved oxygen areas; for example, models can be used to identify areas of the Project that are likely to have problems meeting water quality requirements;

3. To indicate where applied studies are needed by showing key gaps in knowledge of the system;

4. To inform monitoring programs and allow spatial and temporal interpolation among monitoring data;

5. To explain trends and act as a diagnostic tool to determine system response to hypothetical cases or alternative scenarios. For example, if *Spartina alterniflora* hybrids cannot be controlled and studies indicate this invader will have a significant effect on the South Bay ecosystem, then modeling alternative scenarios will be required to predict ecosystem response to this new state and predict how the system might respond to new management actions; and

6. To provide the public with real-time information and analysis of system conditions.

All of these uses will help Project Managers adaptively manage the South Bay while allowing the public and researchers access to Project information.

D. Conceptual Models Illustrating Adaptive Management

During the planning process, the Project participants learned that some aspects of the South Bay ecosystem are fairly well understood and the outcomes of management actions for these parts of the system are relatively certain. For example, there are good data for the rate of marsh development in South Bay marshes. Tracking relatively predictable restoration responses requires one data collection approach, while reducing uncertainty in restoration outcomes requires another. Predictable outcomes are assessed through monitoring, which is repeated data collection to assess system progress. Monitoring tracks system responses through time to allow Project Managers to assess whether expected changes are, in fact, occurring. Uncertainties are reduced through applied studies (Table 2), in which hypotheses are tested to develop cause-and-effect knowledge about the environment.

The relationship between monitoring and applied studies in the South Bay Salt Pond Restoration Project is depicted in Figures 4-6 using conceptual models that illustrate ecosystem processes and outcomes. These figures are based on conceptual models, for tidal habitat, managed pond, and landscape levels, described in the *South Bay Salt Pond Restoration Project Conceptual Models* (Trulio, et al. 2004). These conceptual models link different restoration and management actions to anticipated responses in the South Bay ponds and the overall ecosystem.

In Figures 4-6, current conditions under ISP management are changed through the Project's management and restoration actions ("Project Actions"), and these actions result in expected, and desired, effects on the system ("Results"). Monitoring topics are aspects of the environment that the Project will measure to assess progress toward the desired "results" and detect possible problems. The applied studies are questions whose answers will help reduce uncertainty in reaching the "results". Look along the top of the figures to see the changes the Project expects to occur and will monitor at tidal habitat, pond, and landscape levels. Actual changes will be compared to the expected results to assess restoration progress. Along the bottom of each diagram are corresponding lists of applied study questions that will be answered to reduce uncertainty and offer insight into why the system is responding in a particular way. A complete listing of all the monitoring parameters, applied studies, and modeling that the Project plans to undertake is found in Part 3 and Appendix 3, the Adaptive Management Summary Table.

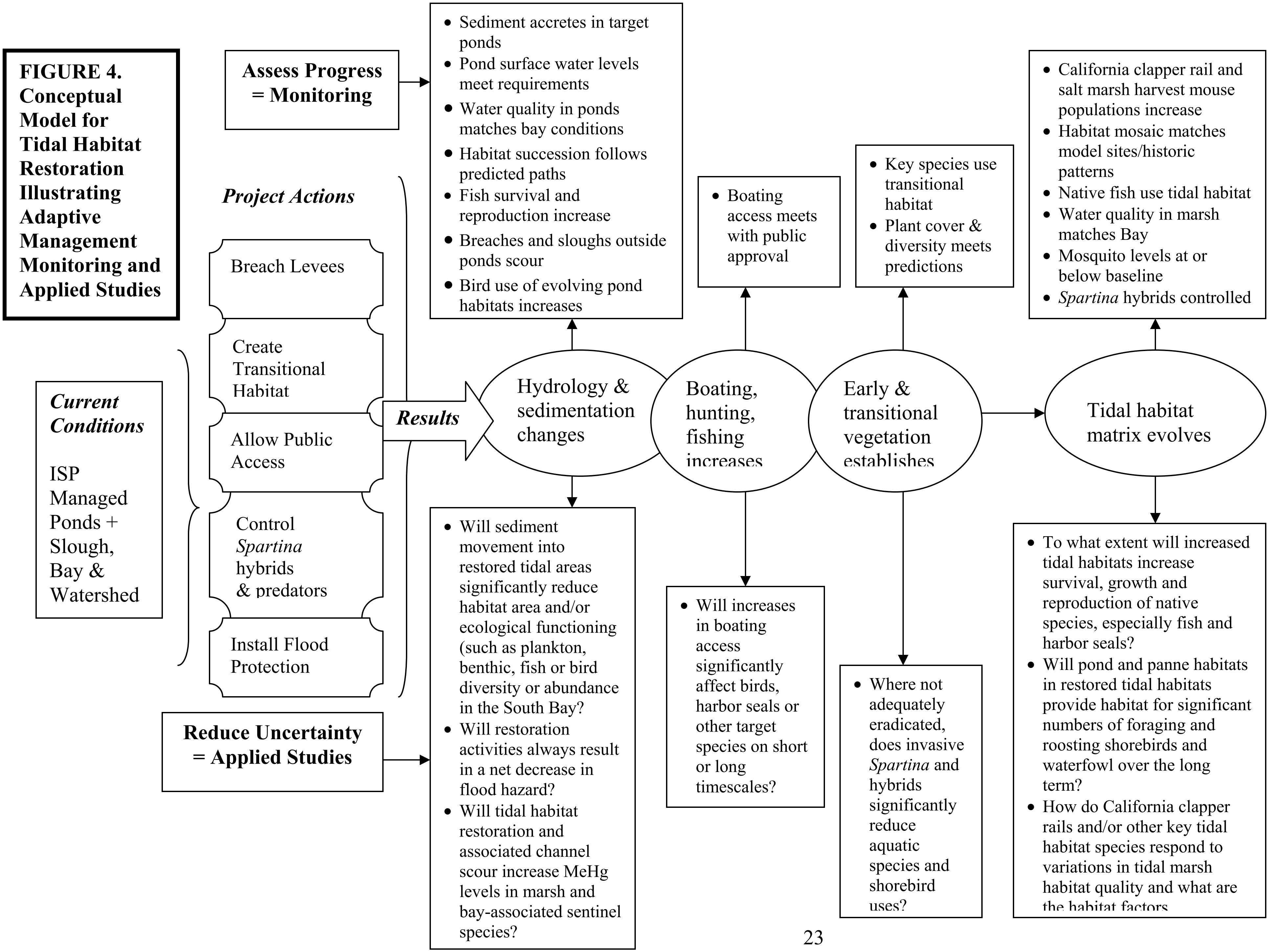


FIGURE 4. Conceptual Model for Tidal Habitat Restoration Illustrating Adaptive Management Monitoring and Applied Studies

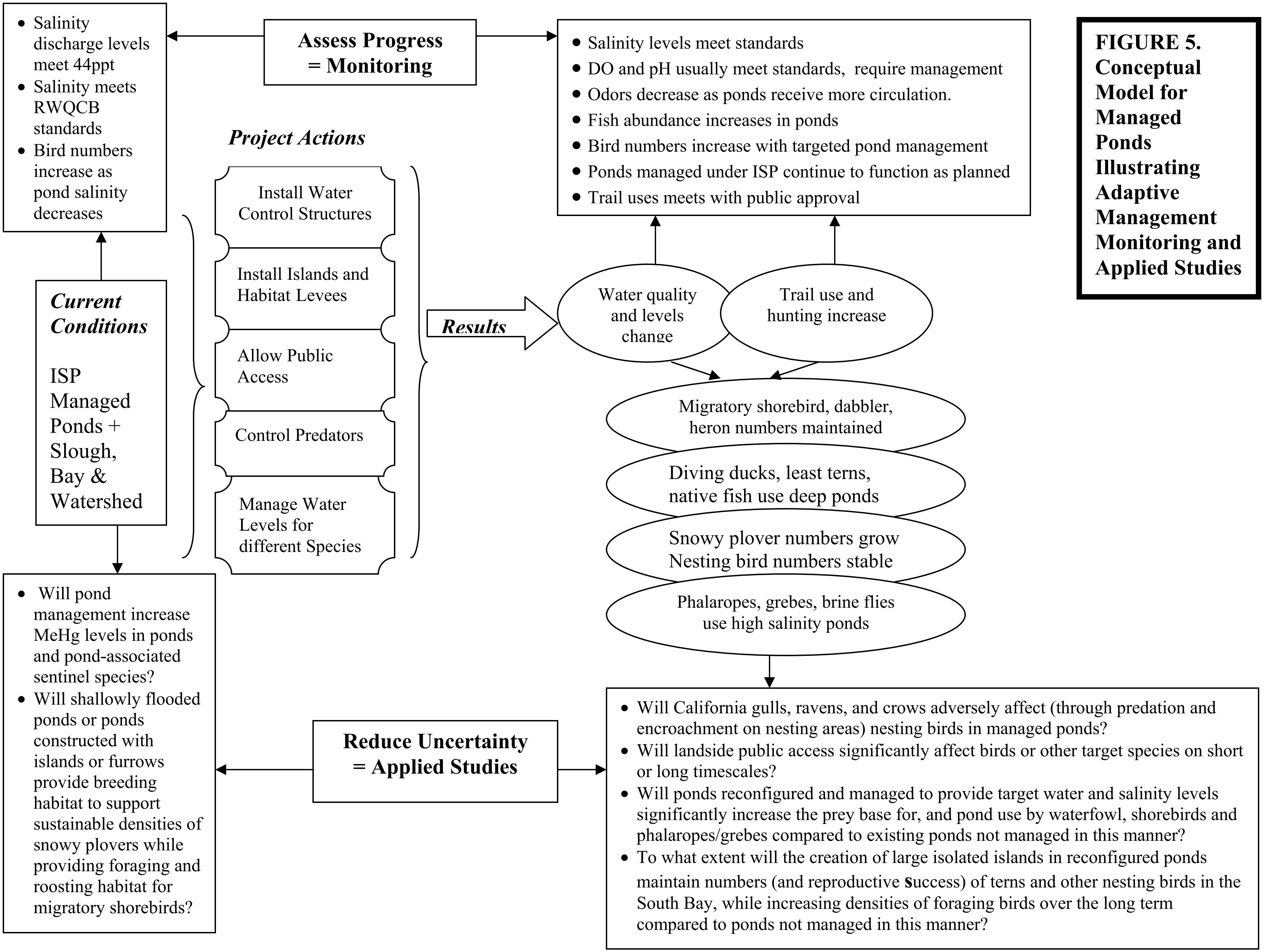
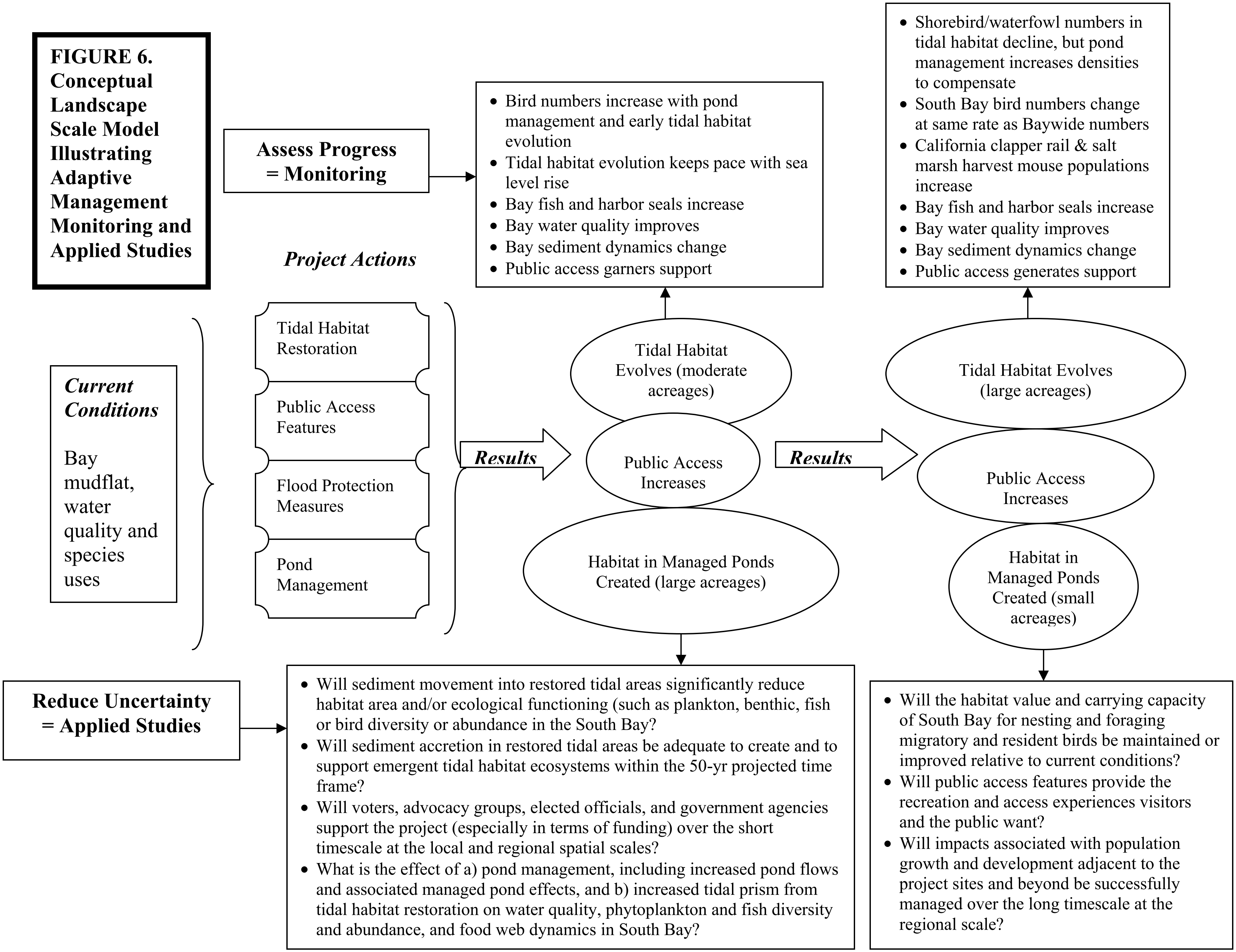


FIGURE 5. Conceptual Model for Managed Ponds Illustrating Adaptive Management Monitoring and Applied Studies

FIGURE 6. Conceptual Landscape Scale Model Illustrating Adaptive Management Monitoring and Applied Studies



Part 3. IMPLEMENTATION SCIENCE: Information for Decision-Making

A. Elements of Adaptive Management Science

Work done during the planning phase established the foundation for the adaptive management data collection and analysis approach described here. This section describes the scientific approach--based on restoration targets, monitoring, applied studies, and modeling--for providing the information that managers will need for decision-making. Appendix 3, the Adaptive Management Summary Table, integrates data collection and management, and ties them to the Project Objectives.

This adaptive management approach begins with a limited set of quantitative restoration targets for the Project Objectives that allow restoration progress to be tracked. We chose only targets that must be assessed to determine whether or not Project Managers can implement more tidal action while continuing to achieve the Project Objectives, in other words whether the Project can move further along the adaptive management staircase depicted in Figure 2. Thus, benefits or impacts from the Project that would not affect the decision to add more tidal habitat are not included. This restriction is important. While there are many factors that could be monitored, a feasible monitoring program can include only the most critical elements.

In Phase 1, Project Managers expect to implement all the monitoring and applied studies listed in the Adaptive Management Summary Table in Appendix 3. However, parameters will be monitored with different levels of effort based on management needs. While all applied studies in the Table will be undertaken, complete results to some questions, especially sediment dynamics, may not be possible until other action, such as restoration of more acres to tidal action, is initiated. The Adaptive Management Summary Table links the data collection needed for adaptive management with decision-making. Here is a summary of the role of each column in the Table:

<u>Category</u>. Categories are the basic elements of the ecosystem that must be monitored to determine whether the Project Objectives are being met or are likely to be met in the future and, therefore, whether the Project can move forward with more tidal restoration. The applicable Project Objectives are listed for each category.

<u>Restoration Target</u>. Each restoration target is a direct measure of a Category and each gives measurable goals for what the Project should achieve to successfully meet each of the Project Objectives. Typical data sources for developing these targets are the literature, quantitative baseline data (such as that collected by USGS, PRBO or SFBBO), or requirements set by a regulatory agency, such as standards for dissolved oxygen levels or population levels for California clapper rail recovery. Targets include both long-term goals (50-year horizon) and intermediate conditions as the ecosystem changes. Restoration targets are expected to evolve as more information about the system is collected.

<u>Monitoring Parameter</u>. The Project participants chose monitoring parameters they believe are the most effective and efficient way to assess change with respect to the restoration targets. This column gives the variables to be measured and a basic monitoring approach. Specific methods are given only when needed to make the approach clear. The parameter, method, spatial scale, and timing of monitoring must be adequate to detect change. For example, the first restoration target under sediment dynamics is “no significant decrease in South Bay intertidal and subtidal

habitat". Assessing this target requires calculating the areas of restored pond, outboard mudflat, and subtidal shallows. A combination of monitoring methods might be used, such as: 1) bathymetry and LiDAR survey every 5 years; 2) survey of sediment accumulation annually in ponds opened to tidal action; and 3) a limited number of localized bathymetry surveys in certain priority areas. This column lists appropriate monitoring parameters, but cannot fully describe the monitoring regime. A monitoring plan—giving methods, protocols, timing and responsible parties—will be developed by the Project for implementation in Phase 1.

Spatial Scale for Monitoring Results. This column gives the spatial scale at which monitoring should occur to detect results usable by Project Managers.

Expected Time frame for Decision-making. This is the time frame in which change could realistically be detected leading to management actions to adjust the restoration actions.

Management Trigger. While the restoration targets identify the desired outcomes relative to the Project Objectives, the management triggers identify the point at which technical analysts believe the system may not be performing as expected, i.e., potentially moving away from achieving a restoration target. At this point, Project Managers should evaluate the status of the Project and consider management actions. Triggers have been set intentionally at a low threshold to ensure early evaluation and potential action, rather than waiting until substantial problems have developed. The threshold is also designed to avoid significant environmental impacts as identified in the *South Bay Salt Pond Restoration Project EIS/R* (2007).

Applied Studies. The relevant Applied Studies from Table 2 are listed for each restoration target. Descriptions of each applied study appear in Appendix 1.

Potential Management Actions. In the event that a management trigger is tripped, the Project Management Team will need to take action based on the available information. This column lists typical classes of management actions available to Project Managers and some examples of those actions. The exact management action will depend on the nature of the problem and the appropriate remedies available. Typically, the first management action will be to conduct a thorough review of the available information that can inform management on the trigger. Often, Project Managers will ask experts, both associated with and external to the Project, to analyze the relevant information and provide a range of appropriate management actions, including their risks and costs.

B. Linking Science-generated Information

Restoration Targets. The Project's restoration targets, monitoring, applied studies, and modeling are integrated to generate the scientific information managers need for decision-making. In a nutshell, adaptive management relies on clear, measurable restoration targets that directly track the Project Objectives; monitoring is used to assess progress toward those targets; applied studies help Project Managers understand why the system is performing the way it is, relative to the targets, and help reduce uncertainty; modeling is used to try to predict the effects of management actions and to integrate and analyze information for analysis.

The Society of Wetland Scientists (2003) recommends that restoration planning materials clearly state science-based restoration targets (also known as success criteria or performance standards) that are indicators of habitat structure and function. These targets should be "measurable attributes of restored or created wetlands that, when measured over an appropriate period, can be used to judge whether project objectives have been met" (Society of Wetland Scientists, 2003). Typically, they are quantitative benchmarks that are used for measuring progress toward restoration objectives and for determining when the system is diverging from the desired restoration trajectory. Restoration targets should be set for final Project conditions, as well as the interim conditions expected as the Project develops. Restoration targets are a temporary set of expectations that will change as our knowledge of the system increases (National Research Council, 2003).

The targets in the Adaptive Management Summary Table (Appendix 3) were developed cooperatively by the Project Managers, Science Team, Consultant Team, Stakeholders, and appropriate regulatory agencies. Quantitative targets, such as minimum numbers, or ranges of variability, do not yet exist for all restoration targets. Restoration targets will be developed using existing data, such as that collected by the USGS for the Project, or other data sources outside the Project. Some restoration targets will be set by regulatory agencies. For example, water quality standards are determined by the RWQCB, and the FWS will set restoration targets for the California clapper rail and salt marsh harvest mouse through the Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California, which is expected to be released in 2008. Maintaining consistency with the Recovery Plan is especially important for the Project because the South Bay is a significant restoration area for these endangered species.

During planning, the Project participants began developing measurable restoration targets and they will continue to refine them early in Phase 1. The task of setting restoration targets is often difficult. For example, the Project Managers will set population levels as restoration targets for many species, including migratory shorebirds. Setting population targets for these birds is difficult because pre-ISP data are often spotty; in some cases new data will need to be collected over time. In addition, population numbers are often highly variable from year to year, which will make it a challenge to know if the Project is either positively or negatively affecting bird numbers. Despite these difficulties, it is important to try to set and meet target species levels. Although there is significant uncertainty in many population numbers, if monitoring is complete, it will be possible to determine whether species numbers in the South Bay are meeting a baseline level and/or changing at the same rate as the larger Bay-wide or flyway population.

Some restoration targets may be difficult to meet. For example, it is not likely that the Project will be able to meet water quality standards in all ponds all the time. However, these situations will result in studies providing more information on why ponds do or do not meet the standards and what can be done. Restoration targets should hold the Project to levels of performance that are under the Project's control and not to levels that are controlled by external factors. For example, one Project Objective is to maintain the current levels of migratory bird species using the Project Area. If this number declines due to Project activities, Project managers are expected to take action to reverse the decline. However, if the decline is due to other factors, such as loss of arctic nesting habitat, then this is not due to the Project actions and managers will not be expected to (and will probably not be able to) reverse this decline. The Project Managers and scientists have tried to anticipate external factors that will need to be tracked and have included them in monitoring or applied studies for the Project. Project participants will continue to identify important external factors throughout the life of the Project as part of adaptive management. Even with this work, the causes of decline or change may not always be apparent and Project Managers may have to make decisions given the information they have. Advice from experts should always be sought in these cases and Project Managers should carefully document the reasoning and data that went into their final decision.

The Adaptive Management Summary Table lists specific restoration targets for all Project Objectives except for Objective 5, implementing measures to control invasive and nuisance species, and Objective 6, protecting infrastructure. Achieving invasive and nuisance species control is measured with respect to impacts on target species or communities. Thus, targets relative to Objective 5 are given under the Tidal Habitat Establishment, California Clapper Rail, Breeding Birds, and Western Snowy Plover categories in the Table. Protecting infrastructure is a design issue that will not alone determine whether the Project proceeds along the adaptive management staircase. Infrastructure evaluation will be part of the operations and maintenance plans that DFG and FWS will develop for their pond complexes.

Even with the best research, restoration targets may not be entirely accurate, and ranges of certainty and natural variation may not be known. Careful monitoring and applied studies will reveal whether the target should be revised and, if so, how. While the Project Objectives themselves are expected to remain unchanged throughout the life of the Project, restoration targets are very likely to change as knowledge of the system increases (National Research Council 2003). Each year, in their evaluation of the Project's performance, Project scientists and managers will review the restoration targets in light of adaptive management monitoring and study results to determine if they are still appropriate and accurate measures of progress toward the Project Objectives.

Monitoring Parameters. Callaway, et al. (2001) state that, "Assessment is the quantitative evaluation of selected ecosystem attributes, and monitoring is the systematic repetition of the assessment process, that is, measurement of the same attributes in the same way, on a regular schedule. The placement and timing of samples are tailored to the spatial and temporal variability… A one-time sample does not constitute monitoring, nor does the haphazard timing of repeated assessments or repeated measurement…using different sampling methods. The essence of monitoring is consistency. At the same time, monitoring programs must be able to evolve." The purposes of monitoring are to:

- assess progress toward Project Objectives;
- evaluate effects of a specified management action;
- characterize baseline/reference conditions;
- track regulatory compliance; and
- detect early signs of potential problems and anticipated changes.

To achieve these purposes, the Project will measure a large number of monitoring parameters. The Project's 50-year horizon necessitates measuring short- and long-term characteristics. For example, we expect that large-scale changes in the area of mudflat (the first restoration target in the table) will not be detected for 10-20 years. In contrast, breeding birds are likely to respond to restoration changes in the next breeding season. In addition to varying time scales, the Project will track structures and functions at these spatial and ecological scales:

- <u>Beyond the Ecosystem Scale (Entire Bay Area and Beyond)</u>: Parameters at this level measure large-scale processes, often external to the ecosystem, that will affect the Project. Three such metrics relevant to the Project are:
  - Pacific flyway species composition and abundances;
  - Sea-level rise, especially effects on tidal habitat evolution and flood protection;

    - California and Bay Area human population change.

  If information on these parameters is needed, Project Managers will seek out the data from other entities. If data are not being collected by others, the Project may initiate its own data collection efforts.
- <u>Ecosystem Scale (South Bay and Multiple Pond Complexes)</u>: Ecosystems are large-scale phenomena driven by water, carbon, energy, and nutrient dynamics. Parameters proposed to measure physical aspects include sediment measures (sediment deposition or erosion and suspended sediment concentrations), water quality conditions, and mercury-level changes in populations in the food web. Ecological parameters will include the extent and distribution of habitats in the South Bay ecosystem, landscape-level marsh development, habitat connectivity, bird species diversity in the Project Area, fish community changes, and plankton community changes.
- <u>Community Scale (Pond level)</u>: Ecological communities are characterized by the diversity and interaction of species in a particular area. Major communities in the Project Area are tidal marsh habitats, managed pond, tidal mudflat, and subtidal/deep water communities. Parameters will include nutrient levels, vegetation composition and cover, succession, bird/fish/benthic community composition, food chain development, water quality measures, predator-prey dynamics, mercury levels, and interaction of non-native/invasive with target native species.
- <u>Population Scale (Species level)</u>: The Project will monitor population changes in a number of listed and indicator species, as well as specific non-native species, such as *Spartina alterniflora* (and hybrids), and nuisance species, especially mosquitoes and California gulls (*Larus californicus*). Typical population parameters are distribution, abundance, breeding success, predation impacts, habitat quality, and quantity.

The Adaptive Management Summary Table lays out the monitoring for the Project, beginning in Phase 1. For these parameters, the Project will develop monitoring plans, which will be peer-reviewed. Plans should include these elements:

- protocols for measuring parameters including the location of measurements, timing and frequency of monitoring, monitoring methods and a schedule for rapid review of data to compare to management targets;
- construction-related monitoring parameters and protocols;
- roles and responsibilities for monitoring, including who will do what, when, and where;
- specific instructions for data analysis, interpretation, presentation, and storage;
- protocols for ensuring QA/QC;
- report requirements and deadlines; and
- funding approach for monitoring.

The Project Managers will develop monitoring plans for implementation beginning in Phase 1. Whenever possible, monitoring methods should be designed to collect data for multiple parameters. For example, aerial photo and satellite data collection methods can be very economical and can provide information on a range of parameters (Table 4). More labor-intensive field data collection once a month may be needed, but a wide range of sampling can be done in one visit. Collecting sediment cores and topographic elevations, perhaps done once a year, will provide valuable data for a number of parameters. Volunteers may be able to collect a range of data using simple assessment methods. Collecting some data may not even be necessary if that information is already being collected by other organizations. For example, the Regional Monitoring Program (RMP), a program of the San Francisco Estuary Institute, may already be collecting some of the pollutant data the Project will need. Finally, some time-consuming and expensive methods, such as call counts for California clapper rails, may be the only way to assess some parameters.

Well-implemented operations and maintenance (O & M) programs are important to supporting accurate monitoring results. Simply stated, O & M activities are those tasks required to keep the Project running as designed. These activities include a wide range of tasks such as operating and maintaining tide gates as required, checking and repairing infrastructure protections (such as riprap or other armoring), and fixing damage due to vandalism. When O & M activities are current and the Project is functioning as designed, monitoring will track how the system is performing based on the effects of management actions. Without up-to-date O & M, monitoring results may detect problems in the system stemming from the effects of poor maintenance rather than from the management actions themselves.

The Project's science program during implementation will be responsible for collecting and interpreting monitoring data for the Project Managers to use in adjusting current actions and designing future Project actions. In particular, Project Managers and scientists will look for evidence that the system is diverging from restoration targets and for evidence of unexpected outcomes--both of which may require management action. These situations may also require additional or new applied studies to understand system responses. Project science managers will make recommendations to the Project Managers on appropriate monitoring parameters, methods, and emerging applied study needs. Data and analyses will be made available to the public via the Project's website and other outreach mechanisms.

TABLE 4. Efficient Monitoring Methods and Parameters they Measure

Monitoring Method	**Examples of Parameters Measured**
Aerial Photos or satellite Images	• Aerial extent of tidal habitat • Connectivity of habitats • Form, location, density of channels • Primary productivity • Location, extent of invasive plants, where appropriate
Photo monitoring	• Use of levees by predators, especially red fox, cats, etc. • Nest activities
Monthly site visits	• Waterbird abundance & diversity • Counts of trail users • Water samples for nutrients, productivity, pollutants
Water quality data sondes	• DO, salinity, temperature, sediment concentrations, currents • Water level elevations
Sediment Cores	• Benthic species diversity • Accretion/erosion rates • Presence of contaminants

Applied Studies. Monitoring indicates what is happening, but typically not why it is happening. Applied studies will help close the gaps in our knowledge about how to reach restoration targets and will help managers understand why the system is responding as it is. The applied studies listed in Table 2 were identified by the Science Team during planning as most critical to achieving the Project Objectives. However, not all the applied studies listed in the table can be thoroughly investigated in Phase 1. For example, Phase 1 actions will not allow study of large-scale sediment movement. Thus, the applied studies for the Project should be sequenced and undertaken when conditions permit (Appendix 2).

The Project will generally use competitive proposal processes (Appendix 4) to identify researchers for applied studies, although a directed solicitation process may be used from time to time. The Project's science managers will review the list of priority applied studies each year, or more often if needed, and will make recommendations to the Project Managers as to which studies should be undertaken and when. Individual contractors, as part of the Project's science program, will be responsible for synthesizing and interpreting the information from these studies, which will be used to revise the monitoring program, adjust current actions, and design future Project actions. Research through applied studies is expected to be published in peer-reviewed publications and the applied studies program will be peer-reviewed periodically as part of the Project's external review. Part 4 gives more detail on the process for identification and review of applied studies.

While the applied studies listed in Table 2 are those most critical to informing movement along the adaptive management staircases (Figure 2 and 3), there are many other areas of research, not related directly to adding more tidal habitat, that could benefit the Project. The Project Managers and scientists will encourage researchers interested in other relevant studies to undertake this work. Such areas of study include restoration of native oyster populations, habitat requirements of western pond turtles, and habitat requirements of native rare plants, and basic or theoretical research into South Bay ecosystem processes. Certainly, researchers will present Project Managers with a wide array of research ideas. The Project will not be able to provide funding for all such studies, but Project Managers should assist to the extent they can with permits, letters of support, and other in-kind services, for valuable studies when appropriate. If demand is great for this type of research, the Project's science managers may develop a review system to help managers select research most likely to assist the Project.

Modeling. The development and application of numerical models is an important component of the Adaptive Management Plan. While some applied studies may contain modeling components, the primary modeling endeavor will be the development and application of an integrated model that captures "understanding of system processes based on information currently available, to identify important areas of uncertainty where additional information is needed, and to predict system outcomes under different scenarios" (National Science Panel, 2005). The development, revision, and application of the model will require continual effort during implementation.

This model will be used to integrate and analyze applied studies, monitoring, and other Project information for use by the Project Managers. In particular, the model should allow managers to predict how the system is likely to respond to management actions and also to external factors such as sea-level rise and other consequences of climate change. This forecasting function will be especially valuable for designing future Project phases. The model will also inform applied studies by allowing preliminary testing and refinement of hypotheses and improve monitoring programs by identifying areas of variability that should be resolved by monitoring. A state-of-the-art numerical model will also be useful for many additional restoration projects and other environmental studies in South San Francisco Bay.

The scope of the mechanistic model will be large given the many physical and ecological processes relevant to the Project, and the model's development will likely be incremental with early efforts focusing on hydrodynamics, water quality, sediment transport and geomorphic change. While model development is expected to be a multi-million project, this effort will be less expensive and more productive than funding parallel development of models by multiple consulting and research teams. This should be a public domain, open source model so that it is available to all researchers and consultants for continued development, testing and application to the Project and other restoration efforts in the South Bay. All data used in model applications will be made available on a website. Data will include initial conditions and boundary condition data, other model inputs, and calibration and validation data.

The model formulation and calibration should be documented and published in peer-reviewed literature to ensure that any important shortcoming of the model formation or degree of calibration is quickly identified. As additional refinement and calibration of the model is performed, this information will be provided on the website in a timely manner. As with monitoring and applied studies, the Project's modeling efforts will be peer-reviewed as part of external Project review.

C. Linking Information and Management Actions

Adaptive management cycle. Figure 7 illustrates the cyclic, adaptive management process of information generation and decision-making. As earlier described, the restoration targets are the expected Project outcomes and management triggers are the thresholds that indicate the Project may be diverging from a restoration target. These triggers are set to trip well in advance of significant impacts to the system and, if reached, signal the Project Managers will take steps to understand what is happening and, if necessary, take action to put the system back on track toward the restoration target (Figure 8). As Figure 7 shows, the PMT and science managers will review and regularly update the restoration targets and management triggers with new information as part of adaptive project management. The adaptive management process also allows for review the Project's six primary Objectives if the Project is not able to achieve one or more of them. However, any changes to these Objectives will require consultation with the Stakeholders, as they were central in developing these goals. The adaptive management cycle is a continual process of updating restoration targets and triggers, appraising applied studies and monitoring needs, designing current and future phases, and generating information to determine if the Project is meeting its Objectives.

Responses to management triggers. What will the Project Managers' responses be when data show a management trigger is reached? The Adaptive Management Summary Table (Appendix 3) lists a suite of potential management actions Project Managers could take. In each case, one of the first actions will be for the Project Managers and scientists to study the information more thoroughly to understand what may be happening with the system. This analysis may be achieved through a meeting of Project participants, or workshops, and/or written evaluation from a panel of experts, when time allows. The exact management actions taken will depend on the nature of the problem, the results of the in-depth analysis, and the management options available. Management actions available for some triggers will be diverse, but others will be proscribed, especially those in response to triggers linked to regulatory standards.

Project Managers will be prepared for situations requiring rapid response as well as those allowing slow response. In some cases, a tripped management trigger must result in rapid action by the Project participants. In the rapid-response scenario, monitoring data are reviewed in a timely manner by the Project scientists, especially the Monitoring Director (see Part 4), and reported to the Project Managers. If Project Managers and scientists determine that a threshold has been reached, they will confer with other experts and Project participants to determine the best course of action. Action may be quickly taken to prevent or minimize damage to the system. Rapid action is essential in the case, for example, of low dissolved oxygen levels, which can cause fish die-offs and other ecological problems within days. Such situations allow little time for public interaction at the time of the event and Project Managers may have to take action without public input. In all such cases, the public will be informed of actions taken and invited to comment on the events to help managers improve their actions in these rapid-response situations.

For other management triggers, responses will be slower, allowing more time for study and stakeholder involvement before corrective action is taken. An ideal example of this is the population trigger for migratory shorebirds. The entire "restoration target-monitoring-trigger-management response" scenario for shorebirds will be a long-term process. First, the restoration target for shorebird population numbers will take several years to produce and will continue to be refined for many years. This target development process is lengthy because there is very little information on shorebird numbers in the South Bay prior to the Project monitoring. In addition, shorebird numbers are extremely variable from year to year and, therefore, the target will be designed to include the natural variation shown by Bay-wide populations. South Bay and Bay-wide populations will be monitored and compared to the target to determine whether South Bay population change is different from Bay-wide shorebird population trends. Gathering enough data to statistically assess these trends will, most likely, take a number of years. While the management trigger will be set recognizing the wide natural variation inherent in shorebird numbers, it is meant to trip very early to prevent problems from becoming too great. Thus, if the trigger is reached, the Project Managers will begin by convening experts to determine if shorebirds are declining and, if so, is the Project responsible in a substantive way. There will be time for significant scientific and public input to assess the information and determine appropriate corrective actions, if they are necessary.

Public access decisions will also be adaptively managed using the same rapid and slow response processes. For example, a rapid response scenario could occur if, hypothetically, a listed species were to establish nesting sites adjacent to a public access, spur trail. Since nesting birds are very sensitive to human disturbance (Carney and Sydeman, 1999; Trulio, 2005) and listed species are protected by law, Project managers and scientists would rapidly evaluate whether the trail was likely to be a significant disturbance to the animals. If so, they might take action to seasonally close or reroute the trail. The public, especially stakeholders, would be informed of the management actions, but as with most rapid response scenarios, there would be little time for public input before action was needed. Managers would receive public input at follow-up meetings to help improve responses in the future. There will also be many slow-response scenarios. For example, information from public access applied studies may show that some species are more sensitive to trails, i.e. experience more disturbance, than others. Project managers, scientists, and other experts would assess whether a trigger had been tripped. If so, the process of holding workshops with experts, meeting with stakeholders, and assessing potential management actions would be initiated.

Action not initiated by management triggers. The Adaptive Management Summary Table and the previous discussion have focused on what the Project Managers should do to get the system back on track if the targets are *not being reached*. This risk-averse approach is designed to prevent the Project from harming the South Bay system. Not only is this approach essential from an ecosystem health standpoint, but it is required by NEPA/CEQA as well as regulatory agencies that require that the Project avoid or mitigate significant impacts of the implemented restoration and management actions (Figure 8). Finally, this approach provides the best assurance possible that the Project Managers will meet the Project Objectives--goals that are important to the funders, agencies, legislators, and all the members of the public who were involved in helping make this Project possible.

While it is important to be cautious, Project information may indicate that, instead of things going awry, they may be going very well, even exceeding the targets expected. For example, data may show that California clapper rails are responding very quickly and positively to new tidal habitat with population numbers and densities exceeding targets. Or, foraging shorebird numbers in tidal habitat may be greater than expected, showing these habitats are supporting more birds than predicted. Or, assumptions that public access has impacts on one or more listed species may not be supported. These Project results, in which restoration targets are exceeded, will also be evaluated by Project Managers and scientists for management action. Exceeding expected outcomes will have implications for how fast and how much tidal habitat is restored, the locations and amounts of public access, and movement along the adaptive management staircase, in general. Since the monitoring parameters in the Adaptive Management Summary Table are set up to track progress toward the targets, they will function well to show when the Project is advancing quickly and exceeding expectations, as well as the when the Project is diverging from expected outcomes.

FIGURE 7. Adaptive Management Process

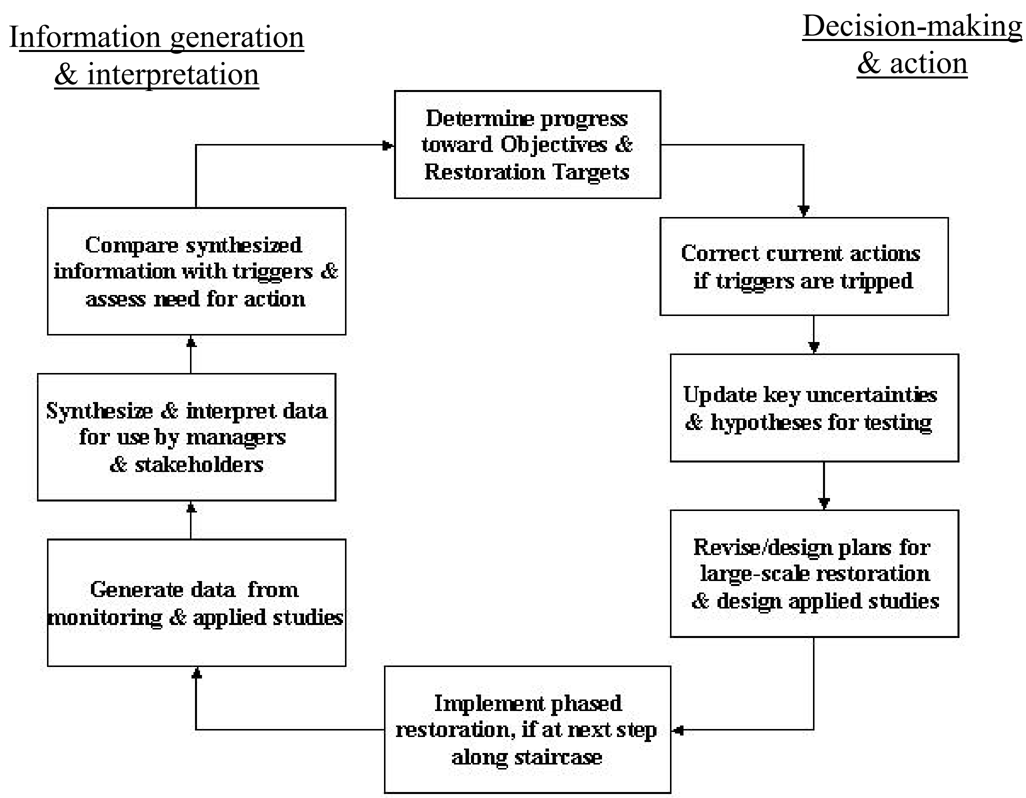
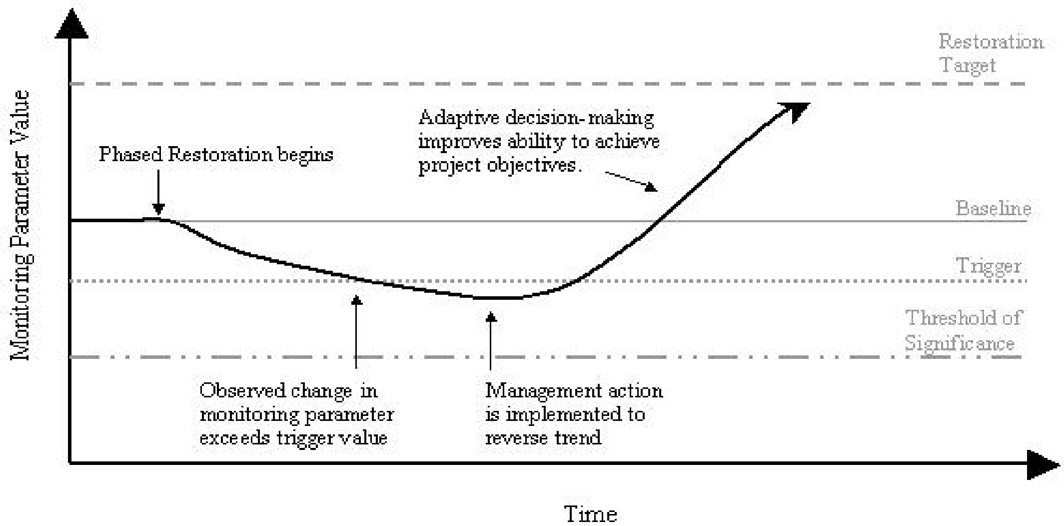


FIGURE 8. Linking Restoration Targets to Management Triggers



D. Phase 1 Applied Studies, Modeling, and Restoration Techniques

In 2008, planning for the Restoration Project will be complete and the Project Managers will begin implementing a set of Phase 1 actions. The Phase 1 actions were chosen because they are visible to the public, are expected to provide early successes in meeting Project Objectives, and allow testing for a series of applied studies to reduce key uncertainties. Table 5 lists the Phase 1 actions evaluated in the *South Bay Salt Pond Restoration Project EIS/R* (2007) and Figure 9 shows the locations. Table 5 also shows the applied studies associated with each action.

Phase 1 applied studies are coordinated with each restoration and management action. These studies are predominately focused on questions related to bird use of changing habitats, mercury issues, and public access-wildlife interactions. Project Managers need information on these uncertainties before they can determine how much tidal action to restore in future phases. Two large-scale experiments are planned to test key questions (see descriptions in Appendix 5). Ponds A16 and SF2 will be engineered with a large number of islands of different shapes, sizes and densities to assess the applied studies question: Will ponds that are reconfigured to create large isolated islands for nesting and foraging significantly increase reproductive success for terns and other nesting birds and also increase the numbers and densities of foraging birds over the long term compared to existing ponds not managed in this manner? At ponds E12/13, the Project will assess the extent to which ponds reconfigured and managed to provide specific water and salinity levels significantly increase the prey base for, and pond use by waterfowl, shorebirds, and phalaropes/grebes; these ponds will be reconfigured as a small-scale salt pond system. Public access-wildlife interaction studies will be included in both these experiments. Studies of mercury methylation in response to management actions will continue into Phase 1, especially at Pond A8, which will be constructed as a reversible, muted tidal system used to assess mercury methylation changes in response to restoring tidal action. This action will also allow study of the extent to which salmon are able to enter and leave A8 through the water control structure.

Another issue for the Project during Phase 1 will be the effect on the Bay of ponds that are reconfigured or still managed as described in the ISP. Under the ISP, groups of ponds were linked together for circulation in a coordinated design of water intake and outflow to prevent salt making. Operation under this system quickly revealed unexpected changes in water quality and bird use. Changes due to Phase 1 actions will further affect pond ecology, requiring that they are monitored and studied to understand how ponds are functioning within the restoration project and with respect to the Bay.

As described earlier, Phase 1 efforts will include development and application of a numerical model that integrates physical and biological processes of the system to identify uncertainties and to predict system responses to potential management actions or external factors, such as climate change. This core model will be focused on predicting physical processes and changes in the far South Bay, below the Dumbarton Bridge, over 50 years. Model development will likely be incremental with early efforts focusing on hydrodynamics, water quality, sediment transport and geomorphic change. Small-scale model development and calibration began during planning at the Island Ponds. The Habitat Conversion Model for predicting bird response to changing habitats should be refined in Phase 1 to provide more predictive power. Ultimately, the Project would benefit from developing models to predict how human population and demographic changes will affect the Bay and restoration potential.

In addition to applied studies, the Phase 1 actions will include design features and pond operations whose feasibility and effectiveness deserve study. These "restoration techniques" (Table 5) do not require hypothesis testing, but their effectiveness requires documentation. Monitoring the effectiveness and sustainability of these techniques will inform the future planning, and possibly indicate changes to Phase 1. These restoration techniques have been identified for inclusion in Phase 1:

- <u>Vegetation Management on Islands and in Managed Ponds</u>. While some vegetation on nesting islands may be acceptable, design features and/or management is necessary to prevent dense, tall vegetation from substantially encroaching on the islands and to maintain habitat for species averse to nesting in vegetation. Vegetation management may also be required in areas of ponds managed for shallow water habitat. Phase 1 provides an early opportunity to learn about which methods are most effective at preventing vegetation growth and, if needed, controlling vegetation.
- <u>Water Management for Discharge Requirements</u>. The shallow water environment of managed ponds provides valuable habitat that supports various species of invertebrates and fish, many of which serve as food for nesting birds. However, compliance with water quality discharge requirements for discharge to Bay sloughs, particularly dissolved oxygen (DO), has been problematic during ISP operations. Reconfigured Phase 1 ponds will include approaches to determine cost-effective strategies to meet regulatory standards while simultaneously providing high quality bird habitat.

- Predator Control at Managed Ponds. Islands within managed ponds provide nesting habitat for a variety of birds. The proposed Phase 1 includes tidal restoration and pond reconfiguration to add nesting islands to managed ponds. These actions will displace predatory California gulls currently nesting in Pond A6, increase wetland nesting habitat for predatory northern harriers in restored marshes, create island nesting habitat that may attract breeding California gulls, and concentrate nesting islands for terns and other birds into fewer locations. As a result, predation pressure by avian (and possibly mammalian) predators on birds nesting on the islands could increase, potentially limiting the number and success of nesting birds utilizing the islands. Phase 1 management actions will include approaches to examine the most efficient and cost-effective methods for preventing and/or controlling predation.
- Sustainability of Constructed Marsh Pond/Panne Habitat. Pannes and ponds were typical, but not ubiquitous, features of historic salt marshes that provided important habitat for certain bird species. These features have rarely formed naturally in restored marshes, and constructed marsh ponds and pannes have been difficult to maintain due to vegetation colonization and erosion of the topographic elements that control tidal inundation. Phase 1 actions include restoration techniques to evaluate if constructed pond and panne habitat can be maintained through natural processes over the long-term.
- Ditch Blocks and Interior Channel Development. Re-establishment of the relict tidal drainage network is typically preferable since channel complexity provides a variety of microhabitats that support many marsh-dependent species. However, during channel formation within former salt ponds, borrow ditches tend to capture and dominate the evolution of the tidal drainage system. Phase 1 actions include restoration techniques to evaluate the extent to which ditch blocks enhance the re-establishment of relict dendritic channel networks within restored marshes. Information from the Island Pond restoration will also be used in this evaluation.
- Gypsum Pre-Treatment and Vegetation Establishment. The plant community is central to the biological functions of a wetland ecosystem, although the presence of gypsum may inhibit vegetation establishment by blocking root growth, preventing full drainage at low tide, or other factors. Phase 1 action at Pond E8A includes mechanically disturbing the existing gypsum layers prior to tidal restoration to examine the effectiveness of pre-treatment. Vegetation establishment (overall and by species) in treated areas will be compared with monitoring data from areas where the gypsum layers are intact.
- Wave-Break Berms and Pond Sedimentation. Wind blowing across open expanses of water, such as low restoration sites at high water, can generate waves that are sufficient to inhibit sediment deposition and re-suspend previously deposited material. These effects can slow or possibly prevent marsh plain formation. Monitoring elements associated with Phase 1 tidal habitat restoration has been included to assess the effectiveness of wave breaks at increasing pond sedimentation rates, and inform fetch spacing.

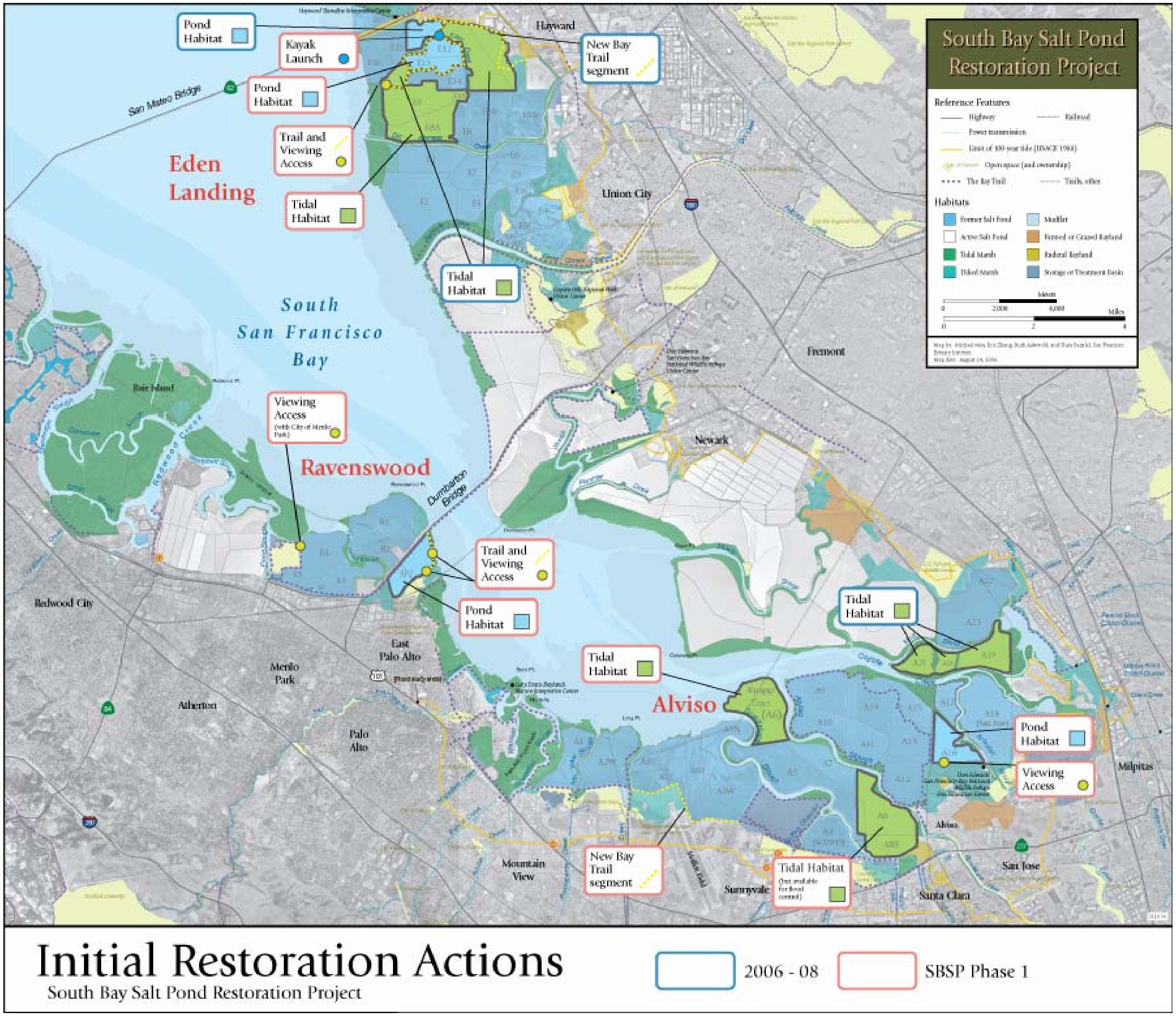
TABLE 5. Phase 1 Applied Studies and Restoration Techniques Questions

Action Type	Phase 1 Action	Applied Studies and Restoration Techniques Questions
Tidal habitat restoration	A6 (Perimeter breaches to mouth of Alviso Slough and Guadalupe Slough.) E8A/9/8X (Restoration plan developed in coordination with Alameda County Flood Control and Water Conservation District. Perimeter levee breaches connect ponds to Old Alameda Creek, North Creek, and Mt Eden Creek)	<u>Applied Studies</u> • Will sediment accretion in restored tidal areas be adequate to create and to support emergent tidal habitat ecosystems within the 50-yr projected time frame? (Modeling required) • Will sediment movement into restored tidal areas significantly reduce shallow water habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance) in the South Bay? • E8: Will restoration activities always result in a net decrease in flood hazard? • E8: Will pond and panne habitats in restored tidal habitats provide long-term habitat for significant numbers of foraging & roosting shorebirds & waterfowl? • To what extent will increased tidal habitat increase fish and harbor seal survival, growth and reproduction? • Will tidal habitat restoration and associated channel scour increase MeHg levels in marsh and bay-associated sentinel species? • A6: Will California gulls, ravens, and crows adversely affect (through predation and encroachment on nesting areas) nesting birds in managed ponds? <u>Restoration Techniques</u> • E8: Will gypsum inhibit the re-establishment of vegetation and relict tidal channels within the ponds? If so, what cost-effective treatments are available for treating gypsum? • E8: Can effective pond and panne habitat be constructed and, if so, can it be maintained through natural processes over the long-term? • A6: To what extent do wave breaks increase pond sedimentation rates? • A6: To what extent do ditch blocks enhance the re-establishment of relict dendritic channel networks within restored marshes?
Reversible muted tidal deepwater ponds	A8 (Limited exchange of tidal water through an armored notch in the perimeter levee between A8 and upper Alviso Slough provided muted tidal action and deep (>2 ft) water depths in Ponds A8, A5 and A7).	<u>Applied Studies</u> • Will sediment movement into restored tidal areas significantly reduce shallow water habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance) in the South Bay? • Will restoration activities always result in a net decrease in flood hazard? • Will tidal habitat restoration and associated channel scour increase MeHg levels in marsh and bay-associated sentinel species? • To what extent will increased tidal habitats affect survival, growth and reproduction of native species, especially fish and harbor seals?

Action Type	Phase 1 Action	Applied Studies and Restoration Techniques Questions
Reconfigured managed pond with islands with public access	SF2, A16 (Pond reconfigured to include shallowly flooded cells with isolated islands.)	Applied Studies • To what extent will the creation of large isolated islands in reconfigured ponds maintain numbers (and reproductive success) of terns and other nesting birds in the South Bay, while increasing densities of foraging birds over the long term compared to ponds not managed in this manner? Specifically, what are the effects of island density and shape on bird nesting use and reproductive success? How do vegetation types, density and distribution affect island use by nesting birds? • Will landside public access significantly affect birds or other target species on short or long timescales? • Will public access features provide the recreation and access experiences the public wants over short or long timescales? Restoration Techniques • Which management methods are most effective and cost-effective for controlling vegetation? • Can we feasibly (cost-effectively) manage water for discharge requirements and create high quality bird habitat? • Which management methods are most effective and cost-effective for controlling predation?
Reconfigured managed pond to sustain a salt pond system with public access	E12/13 (Ponds reconfigured into cells that provide a gradient of salinities and water depths.)	Applied Studies • Will ponds reconfigured and managed to provide target water and salinity levels significantly increase the prey base for, and pond use by waterfowl, shorebirds and phalaropes/grebes compared to existing ponds not managed in this manner? • Will increases in boating access significantly affect birds, harbor seals or other target species on short or long timescales? • Will landside public access significantly affect birds or other target species on short or long timescales? • Will public access features provide the recreation and access experiences the public wants over short or long timescales? Restoration Techniques • Which management methods are most effective and cost-effective for controlling vegetation? How effective is high salinity in discouraging vegetation growth? • Can we feasibly (cost-effectively) manage water for discharge requirements and create high quality bird habitat?

Action Type	Phase 1 Action	Applied Studies and Restoration Techniques Questions
Public access	Bay Trail spine from Sunnyvale to Stevens Creek Viewing opportunity and interpretive display at Bayfront Park	<u>Applied Studies</u> • Will landside public access significantly affect birds or other target species on short or long timescales? • Will public access features provide the recreation and access experiences the public wants over short and long timescales?
Regional effects	Regional ecological and social impacts associated with implementing the South Bay Salt Pond Restoration Project	<u>Applied Studies</u> • Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions? (Modeling required) • What is the effect of pond management, including increased pond flows and associated managed pond effects, on water quality, phytoplankton and fish diversity and abundance, and food web dynamics in South Bay? • Will voters, advocacy groups, elected officials, and government agencies support the project (especially in terms of funding) over the short timescale at the local and regional spatial scales? • What are the costs and benefits associated with the project sites and will they be shared equitably among communities, businesses, municipalities, and/or government agencies at local and regional scales?

FIGURE 9. Phase 1 Actions



E. Future Actions and Long-term Uncertainties

Future Actions. Future phases of the South Bay Salt Pond Restoration Project will integrate habitat restoration and management with flood protection and wildlife-compatible public access, which is the mission of the Project. Future actions will be based, in part, on the evaluation of adaptive management information collected in previous phases. Information collected in Phase 1 from monitoring and applied studies on bird response to management, methyl mercury, and public access-wildlife interactions will be instrumental in determining the extent and location of future tidal restoration.

Ultimately, future actions will be determined by evaluating this information in light of a number of decision criteria. Many of these criteria will be the same as those used in developing Phase 1, which were:

- Availability of funding
- Likelihood of success
- Ease of implementation
- Visibility and accessibility
- Opportunities for adaptive management
- Value in building Project support
- Certainty of investment
- Flood protection

For actions after Phase 1, the same criteria will be applicable, but others will be relevant as well, including the following:

<u>Readiness to proceed</u>
This criterion is similar to ease of implementation. Under this criterion, actions would be favored that are most timely for the particular implementing agency in completing the necessary planning and design. This criterion would not outweigh certain others, particularly those described below.

<u>Ability to utilize results from earlier applied studies and other new knowledge</u>
Under this criterion, projects that utilize the results of earlier applied studies would be favored, either in applying new design concepts based on earlier results or developing new information or knowledge to add to the knowledge base from earlier results. Also, it would take into account any other new knowledge that becomes available to the Project.

<u>Dependency on precedent actions</u>
Some actions cannot be implemented until specific precedent actions occur. A good example is that many ponds cannot be opened to unrestricted tidal action until a suitable flood protection levee is constructed. In fact, after Phase 1, there are few opportunities to open ponds to unrestricted tidal action without precedent flood protection actions.

<u>Dependency on adaptive management progress</u>
The basic layout of tidal and pond habitats in the 50% tidal:50% managed pond and 90% tidal:10% managed pond alternatives presumes a progressive conversion of ponds to tidal

habitats over time. The two alternatives are laid out to represent a continuum, a progression over time from 50%:50% to 90%:10% provided that monitoring results confirm that the Project Objectives are being achieved. The implicit assumption in this construct is that ponds that are managed ponds would not be converted to tidal action until after:

a) the 50:50 mix of tidal and pond habitats is achieved, and
b) monitoring has confirmed that further conversion of ponds to unrestricted tidal action is acceptable.

Flood Management Requirements

Many flood management actions proposed as part of the Salt Pond Project, such as levee construction, may wait for completion of the South San Francisco Bay Shoreline Study. The Shoreline Study process will be used to determine the specific elements of one or more projects that may be authorized for construction under by the federal government. The advantage of the Shoreline Study process to the Salt Pond Project is that it will carry the analysis to project-level detail and may result in a substantial Federal cost share for those elements contained within the federally-authorized project(s).

However, the Shoreline Study is not expected to be complete for several years. As a result, the Project partners are evaluating candidate actions for early implementation in the Alviso Pond complex by the Santa Clara Valley Water District in cooperation with the FWS and the State of California. The value to the Project of early implementation in this manner is that it provides necessary flood protection coupled with further tidal habitat restoration actions. In fact, the opportunities for creating additional tidal habitats after Phase 1 are severely limited until adjacent flood protection levees are constructed.

For the Ravenswood Pond complex, tidal habitat restoration will be closely linked to flood protection. In particular, the Highway 84 approach from the west to the Dumbarton Bridge and the PG&E substation are potentially at risk from flooding if outboard levees are breached, as well as the Belle Haven neighborhood of Menlo Park.

For the Eden Landing complex, the southern area (between Old Alameda Creek and the Alameda County Flood Control Channel) will be evaluated for a combined tidal habitat restoration and flood protection project led by the Alameda County Flood Control and Water Conservation District.

Public Access Needs

A number of the public access projects that are included in Phase 1, such as completion of Bay Trail spine segments, can proceed independently of changes in habitat. Many of the Bay Trail spine segments can and will be built when funds are available on existing or temporary levees that are ultimately proposed to be replaced with well-engineered flood protection levees. When the flood protection levees are constructed, it is the Project’s intention that new and improved trail segments will be constructed on the levees, either on top of the levee or on a bench along one of the levee side slopes. Spur trails into the habitat areas or looped around managed ponds will be considered for construction as habitat development occurs and as additional information becomes available regarding the compatibility of trail uses with species use of the developed habitats.

The resulting application of these criteria will make implementation of actions in the future a varied mixture of activities at different times. A good example would be the set of actions following Phase 1. One may be the construction of a flood protection levee, another could be the development of an additional viewing area, and a third could be refinement of a Phase 1 applied study. These could be somewhat separated in time and space across the Project Area and be unrelated to each other, yet for other valid considerations they could be the most desirable set of actions to follow Phase 1.

Future actions are expected to open significant acreages of pond to tidal action in order to initiate development of significant areas of tidal habitat for California clapper rail and salt marsh harvest mouse and to allow large-scale testing of sediment dynamics and supply questions. These goals argue for restoring tidal action to an entire slough complex. The location of these ponds will depend on results with respect to the factors listed, above, as well as where flood protection work occurs. Possible locations include:

* Ponds along Old Alameda Creek in the Eden Landing complex
* Ponds along Alviso Slough in the Alviso complex
* Ponds along Guadalupe Slough in the Alviso complex
* Ponds along Ravenswood Slough in the Ravenswood complex

Long-term Uncertainties. As the Project moves into the future, understanding external factors affecting the Project will be extremely important. Climate change may be one on which all others hinge. The range and magnitude of climate change effects are not easy to predict. However, it is certain that change will occur. Some of the expected effects of climate change that are relevant to the Project include:

- sea-level rise, which will affect marsh development and flood risk;
- increasing air temperatures, which will influence insect populations, such as mosquitoes;
- changes in ocean and bay surface temperatures, which will affect primary productivity and plankton communities, the basis of the Bay food web;
- changes in freshwater storage and flow, which could change freshwater flow amounts and rates into the South Bay;
- melting permafrost in the arctic, which will affect the nesting success of many migratory birds and could reduce the number of birds migrating to the San Francisco Bay; and
- changes in storm patterns and intensity, which along with sea level rise, flood risk changes and freshwater flow changes, may impact the amount and location of urban settlement around the Bay.

While current estimates of sea-level rise have been factored into the evaluation of the Project alternatives in the *EIS/R* (2007), new model results based on revised sea-level estimates will be important throughout the Project's life. Model predictions of sediment dynamics, marsh development, primary productivity, bird use of South Bay habitats and human demography will all be affected by climate change. And, there are likely to be other significant forces that will impact the Project. One obvious factor is increasing urbanization and changes in human demographic patterns around the Bay. Others are the impact of earthquakes and oil spills. In addition to these, there will be factors that are currently not anticipated.

How will the Project deal with these changes? The adaptive management approach provides a process for continually examining the system, anticipating change, and responding to changes, if, when, and where they occur, based on thorough evaluation of the information and options available. Using information collected and well-developed models, Project Managers can assess, not only system response to Project activities, but can detect changes not resulting from Project actions and can predict changes to the system. Applied studies can be used to assess the causes of these responses and help Project managers understand when the corrective actions can and cannot effectively change or mitigate a negative trend. Evaluating the Project's performance includes trying to anticipate factors that may affect the Project, putting monitoring, applied studies, and modeling in place to try to detect changes due to those factors, and developing potential management responses if unacceptable changes occur. For example, although Project Managers cannot stop sea-level rise, based on estimates they may decide to restore tidal action only to certain parts of the Project area that can be armored with flood protection appropriate to protect against expected storm surges.

The future is uncertain and the direction and extent of change is often unpredictable. Project data and modeling will be employed to improve predictive and response capacities. Ultimately, the adaptive management process will be the way that the Project Managers will learn of and deal with changes to the system due to their actions or due to factors beyond their control.

Part 4. IMPLEMENTATION MANAGEMENT: Institutional Structure and Procedures

A. Organizational Structure

Adaptive management cannot be implemented without an effective decision-making structure that completes the loop between information development and the use of that information in decision-making. The institutional structure for decision-making described here is designed to achieve these four functions:

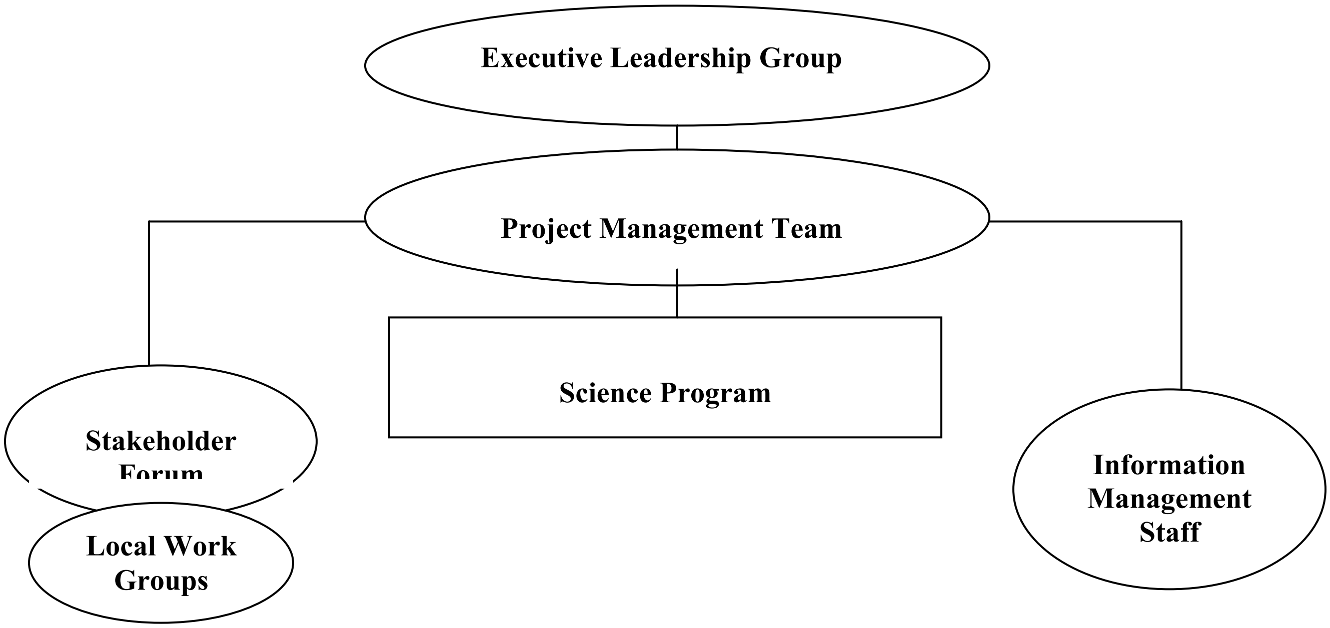
1. Generate science-based information for managers (from monitoring and studies);
2. Convert information into effective management decisions;
3. Involve the public to help provide management direction; and
4. Store and organize information for use by the decision-makers and the public.

Figure 10 shows the organizational structure that will be used to carry out these functions. This structure includes two primary elements, the Project Management Team (PMT), comprised of the USFWS, DFG, SCC, and other involved organizations, which is responsible for decision-making and taking action on those decisions, and the Science Program, comprised of science directors and contractors, which is responsible for data generation and interpretation. The science managers that direct the Science Program will be members of the PMT. Collectively, the PMT and the Science Program managers will evaluate: a) progress toward Project Objectives and restoration targets, b) monitoring and applied study priorities, c) corrections needed to current phases, and d) design of future phases. The PMT is ultimately responsible for all decisions that are implemented.

This structure evolved through a collaborative effort by the Project participants involved during the planning phase and is designed to allow a smooth transition from planning to implementation. The Project scientists and managers reviewed adaptive management programs in other ecosystem restoration projects (CERP, 2004, Flanigan, 2004; Glen Canyon Adaptive Management Plan, 2001) and found that every adaptive management program is structured differently to address the unique ecological and social features of the system. Society has not yet perfected the social, economic, and institutional components of adaptive management needed in specific contexts (Gunderson et al., 1995; Holling, 1978; Walters, 1997). However, one clear lesson from other ecosystem restoration projects is that institutional arrangements themselves need to be flexible and adaptive, as most attempts to institutionalize adaptive management into a standard template have failed (Walters, 1997). The structure and processes described here are expected to evolve over time to meet the Project's needs.

Another lesson is that adaptive management cannot succeed unless participants in the decision-making structure communicate effectively with each other to share information and take action in a timely manner. When different groups or functions remain in "boxes" or "silos" separated from other parts of the structure, decision-making breaks down. Mechanisms to ensure communication include integration of the science managers into the PMT, regular meetings of the Stakeholders attended by PMT members, transparent peer-review procedures, and vehicles for providing information to all project participants and the public, including regular reports from the PMT and Science Program, newsletters, and a Project website.

FIGURE 10. Adaptive Management Organizational Structure and Functions



Executive Leadership Group Functions:
* Provide decisions on overall direction of the Project and use of funds
* Make final decisions on issues involving competing interests between agencies or other big picture issues

Project Management Team Functions:
* Determine changes to current Project phases
* Determine movement along tidal action continuum
* Review and approve Applied Studies and Monitoring recommended by the Science Program
* Determine management actions relative to Triggers
* Evaluate and make changes to Targets and Triggers
* Issue RFPs for research and monitoring
* Set up and respond to Project reviews
* Develop and let contracts for all Project work
* Direct public outreach
* Develop/provide Project funding
* Report Project progress to funders and public

Stakeholder Forum and Working Group Functions:
* Provide community feedback to PMT
* Comment on recommendations from SMT
* Comment on draft decisions from PMT

Science Program Functions:
* In conjunction with the ELG and PMT, generate funds for Science Program implementation
* Interpret results from studies and monitoring for PMT
* Recommend and prioritize Applied Studies, Modeling, and Monitoring needs
* Assess movement along tidal action continuum and recommend actions for future phases and changes to current phases
* Implement adaptive management process when Management Triggers are reached
* Recommend changes to Targets and Triggers
* Set up peer-review for studies, monitoring, RFP, and associated reports
* Develop RFPs for studies, modeling, and monitoring
* Integrate with Information Management Staff
* Hold Science Symposia
* Coordinate research groups ("Science Consortium")
* Produce science reports and publications

Information Management Staff Functions:
* Store and manage data
* Conduct simple data analysis
* Provide data to PMT, the public, and others
* Prepare annual trends reports

B. Roles and Responsibilities
Each group in the Organizational Structure in Figure 10 has multiple functions in developing the information for decision-making, providing information to Project Managers and the public, and making and implementing decisions based on that information.

Executive Leadership Group. The Executive Leadership Group (ELG) is comprised of the heads of the Project Management Team agencies, consisting of the State Coastal Conservancy, the landowning and management agencies, local flood control districts, the Army Corps of Engineers, and Project funders. This group has overall authority for how funds are spent in Project implementation. The ELG coordinates directly with the PMT on high-level decisions. The ELG will meet one or possibly two times per year, depending on the need, to discuss current and proposed management actions and activities in future Project phases.

Project Management Team. The Project Management Team (PMT) will be the decision-making body for implementation and adaptive management. The PMT will be led by an Executive Project Manager and will include representatives from the FWS and the California DFG (the land management agencies), the State Coastal Conservancy (SCC), the local flood control districts (especially the Santa Clara Valley Water District and the Alameda County Flood Control and Water Conservation District), the ACOE, and the Lead Scientist and Monitoring Director. It will operate on a consensus basis, as it has during the planning process. Regulatory agency staff will be invited to participate in PMT meetings; they will be kept apprised of Project activities and will be contacted directly when their attendance is essential. Agencies should include staff involved with issuing and overseeing regulatory approval who can provide "early warnings" to the PMT on regulatory issues. If necessary, decisions will be elevated to the Executive Leadership Group.

The PMT provides leadership for the implementation process and is responsible for many components of the effort, especially determining the management and restoration activities required to meet the Project Objectives. The land management agencies will use the PMT as a forum to coordinate and cooperate for the benefit of the overall Project, but will retain their independent land management authority. A Memorandum of Understanding (MOU) among the PMT agency members will define the roles and responsibilities of the members with respect to achieving the Project Objectives and implementing adaptive management. The Executive Project Manager will assist the PMT in achieving their goals.

Two additional functions of the Project Management Team are obtaining funding for implementation and adaptive management, including funding for the Project including the Science Program, and providing for public participation and outreach. Funding is critical to ensuring that adequate long-term, stable financial support is provided to achieve the Project Objectives. This work includes researching and developing close and long-term relationships with potential funders and incorporating a rigorous proposal and reporting process. To achieve these goals, Project Management Team members will work with other stakeholders, including representatives from environmental or community groups, public works agencies, private foundations, and local businesses or industry, to conduct public outreach and development.

The PMT will lead the effort to identify and secure funding for implementation, including funds for science (applied studies, monitoring, and modeling), adaptive management, and management of the organizational structure. In 2007, the Project Managers and scientists estimated the cost of the program of monitoring, applied studies, and modeling laid out in the Adaptive Management Summary Table at approximately $3 million/year. This figure does not include administrative costs, such as funding the science managers. It is likely that the Project will need to budget at least 10% of its funds for the Science Program, although costs will change depending on the Project's science needs. There are several opportunities for funding that will be pursued including, but not limited to, state bond money, local benefit assessment districts or other local funding devices, federal appropriations to the FWS or ACOE, funds from private foundations, corporations, and individuals, and funds for mitigation or in lieu of fines from public and private entities. Funding for applied studies can, in part, be achieved through coordination with universities and research groups. The SCC will work with its non-profit arm, the Coastal Conservancy Association, to manage private funds. In addition, the Conservancy has the authority to accept and disburse public and private funds.

Outreach efforts to bring the public into the Project will engender support and long-term stewardship and increase the public's overall awareness of their role in protecting the environment. Outreach may include a quarterly or semi-annual newsletter in English and other important languages summarizing the Project's work, field trips, and opportunities for public involvement. Television and radio spots may also be useful in informing the public-at-large about the Project. Getting people actively involved in the Project will require a number of techniques. For example, tours of the Project area are popular but, also, "virtual public access" available on the Project website will allow people to "visit" the site even if they cannot travel. Virtual access can also let people see things that are normally inaccessible; for example, "nest cams", video cameras set up at nest sites that broadcast to the website, are popular ways to see nature in action. Technical workshops and/or public science talks will be popular with some. Many restoration projects also have active volunteer organizations that help publicize and manage aspects of the Project or collaborate with other local organizations to do this. While managing volunteers takes staff and money, the good will they convey and actual work they do can be very beneficial for the Project. The PMT will define geographic sub-areas in the South Bay, establish local Work Groups for those areas, and involve these groups and the Stakeholder Forum in the design, implementation, and monitoring of on-the-ground activities.

Key activities of the PMT include:

- Planning and implementing overall restoration and management, flood protection, and public access design;
- Making decisions about changing current Project phases/actions, determining future actions, revising restoration targets and triggers, meeting regulatory requirements, and all other operations of the Project, based on Science Program findings, Stakeholder input, and other relevant information;
- Providing regular reports to the Stakeholder on Project progress and future plans, and to regulatory agencies on compliance requirements;
- Overseeing budgeting and funding;
- Managing and implementing the contracting and RFP processes;
- Maintaining relations among state and federal legislative and local governments, communities, business, agencies, NGOs, and others;
- Developing community restoration and monitoring participatory activities;

- Conducting Stakeholder Forum and Work Group meetings;
- Coordinating with the Information Management Team to provide information to the public via the Project website and other methods; and
- Conducting outreach activities to raise the visibility of the Project.

In addition, the PMT should facilitate these important tasks as early as possible in Phase 1:
- Quantify restoration targets, as needed.
- Develop monitoring plans.
- Develop methods for resolving disputes about technical and social issues, and disagreements about potential management actions; and
- Develop a schedule and procedures for external review and assessment of the Project's decision-making and information generation systems to improve the effectiveness of adaptive management.

As part of the decision-making process, the PMT will be apprised of current results of studies and monitoring carried out by or related to the Project. The Science Program managers and the Executive Project Manager will be responsible for making sure that results and their interpretation are presented to the PMT in a timely fashion. The PMT will use the results to make four types of decisions:
- *Day-to-day decisions*: These are operational decisions made primarily by the landowners that will be consistent with the EIR/S, AMP, other restoration plans, regulatory requirements, and any operations and maintenance plans that are developed.
- "*Emergency Action" decisions*: These are actions, often related to operations and maintenance, requiring quick response, such as an unanticipated levee failure or unexpected violation of a regulatory requirement.
- *Decisions regarding management triggers*: These are decisions based on PMT agreement that a management trigger has been tripped and would be the initiation of the process to evaluate all existing information and subsequent evaluation of potential management actions.
- *Future action decisions*: These are decisions to initiate a future action, either a restoration plan action or a new or modified applied study. These decisions would incorporate review of existing information, consideration of potential modification of the actions consistent with that review, and in the case of restoration actions, would require environmental review tiered off of the programmatic EIS/R. The PMT will develop guidelines for how to make decisions based on the totality of the South Bay response to Project actions.

Whenever appropriate, the Stakeholder Forum and Local Work Groups will provide input to the PMT before decisions are made (other than day-to-day and "Emergency Action" decisions). They will participate in annual meetings and reviews of the Project's progress as delineated in Section C, below. PMT decisions will be documented in the Project's annual report and in action summaries of its meetings.

The PMT's decisions will be based primarily on the following factors:

- Available information as provided by the Science Program and other sources;
- Status of progress towards achieving the Project Objectives;
- Available funding and any institutional constraints associated with the funding source;
- Input from Stakeholders;
- Assessment of the risks of taking various actions as well as not taking action; and
- Regulatory considerations and constraints.

Science Program. The Science Program will be directed by two science managers, the Lead Scientist and Monitoring Director, and will include an array of contractors hired to complete specific tasks. The Lead Scientist and Monitoring Director, supported by a Program assistant, will determine and manage the work to be done by the Program. They will be members of the PMT and will ensure long-term continuity in the Science Program. The contractors will be hired to conduct all work identified by the science managers, including collecting and analyzing monitoring data, conducting applied studies, writing reports that analyze and synthesize monitoring and applied studies information for use by the PMT, and conducting peer-reviews of science products and the Science Program itself.

The goal of the Science Program is to bring the best and most relevant science to decision-makers and the public in a timely fashion. The Science Program will provide the PMT with a scientific basis for adaptive management decisions on current and future Project actions as well as assisting with the development of restoration targets, and measuring Project success. The primary objectives of this Program are to develop priorities for applied studies and monitoring for the Project; to ensure that information from the Project's applied studies and monitoring is synthesized, interpreted, and published in appropriate media for use by the PMT, other scientists, and the public; to develop, implement adaptive management processes; and to implement peer-review processes for Science Program projects and products as well as for the overall Project. The science managers will need to ensure that the best research organizations and qualified researchers are engaged in order for the Project to be successful.

The Lead Scientist is the overall science manager for the Science Program and will perform these functions:

- Generate local, national and international interest, and local and regional investment in the Science Program;
- Ensure Science Program efforts are credible, legitimate and relevant;
- Encourage the best scientists available to work on issues of interest to the Project;
- In concert with the ELG and PMT, identify and foster funding opportunities to support the Science Program.

Specific responsibilities of this position are to:

- Promote and build the visibility of the Science Program and the Project;
- Represent the Science Program to funders, academic institutions, at meetings, and other public venues;

- Seek funding and research opportunities to support the Science Program, including opportunities for formal partnerships with local Bay area academic institutions and researchers as well as opportunities through federal and state programs, e.g. Sea Grant and others
- As a member of the PMT, provide updates on Science Program activities and advise the PMT on all aspects of the Project connected to science, especially adaptive management decision making, changes needed in current Project phases, and design of future actions;
- Oversee the applied studies process, including the generation of syntheses of information and the production of peer-reviewed products/reports;
- Oversee adaptive management processes, such as when management triggers are tripped;
- Set up and oversee peer-review and expert panels/processes for Science Program products and the Program itself, as well as other aspects of the Project needing expert input, such as refining restoration targets, adaptive management workshops, and Project reviews;
- Develop competitive proposal processes for applied studies and synthesis reports, and establish peer-review panels to evaluate study proposals and reports;
- Convene scientists and research institutions (“Science Consortium”) and encourage them to undertake research in the South Bay that cannot be funded by the Project;
- Hold Science Symposia, or other such venues, to highlight South Bay research;
- Attend Stakeholder Forum and Local Work Group meetings;
- Report on Science Program progress to the ELG and funders.

The Monitoring Director is responsible for developing and overseeing the operation of a system-wide monitoring program, including identifying monitoring parameters, developing monitoring protocols, and overseeing a competitive proposal process to hire consultants or research teams to collect the data. Specific responsibilities of this manager are to:

- Implement the process for identifying monitoring parameters and developing protocols;
- Ensure data are collected, analyzed, and published in useful peer-reviewed formats in a credible and timely fashion;
- Develop competitive proposal processes for monitoring work;
- Evaluate the monitoring data, as required (monthly to yearly), to determine progress toward restoration targets and management triggers;
- Ensure that those collecting data provide, on an established schedule, information and advice about data collection results and system conditions;
- Coordinate with the Information Management Staff on monitoring data storage, analysis, reporting, and presentation for the public and the Project Managers;
- Provide findings and recommendations to the PMT;
- Attend funder, stakeholder, and other meetings as needed;
- Help generate funds for the science program;
- Prioritize and recommend monitoring programs;
- Coordinate with other monitoring programs;
- Achieve a balance between time needed for contractor QA/QC and delivery of timely and accurate data.

These two science managers will work together in a cooperative effort to integrate their tasks. Together they will set the direction for the Science Program and assess whether the cumulative data collected are adequate to meet the Project's needs. They will determine what products need to be produced by the Science Program and ensure that contractors provide those products. This oversight will require they review the quality of work produced by contractors. Joint tasks will also include assessing whether management triggers have been tripped; prioritizing research questions and monitoring needs; providing recommendations for adaptive management and Project implementation to the PMT; ensuring reports that interpret the results of studies and monitoring are prepared, peer reviewed, and published in appropriate formats for all audiences. Advising the PMT will require that the science managers synthesize the reports produced by the Science Program in a form usable by the PMT.

The Science Program will be supported by a Program Assistant who will be responsible for various administrative and research tasks. In particular, this assistant will help set up meetings, coordinate the peer-review process, and organize workshops, and symposia. Other tasks will include helping the science managers establish contacts with researchers and consultants, assisting with RFP production and collecting information from other restoration and management projects to ensure that the Project has the most up-to-date and comprehensive information available. Other relevant projects, especially those around the Bay, must be included in the on-going information synthesis. Examples of such projects include the Napa Salt Ponds Restoration Project, CALFED Restoration Program, and the Hamilton Army Airfield Restoration.

The job of the science managers is to direct the work of the Science Program. The actual work--including collecting and analyzing monitoring data, undertaking applied studies, synthesizing the data generated, preparing peer-reviewed reports, and peer-review itself—will be conducted by contractors, especially research scientists and consultants. The contractors will be chosen on the basis of demonstrated skills and relevant experience through competitive proposal processes designed to bring the best scientists and experts to the Project for the specific tasks at hand (Appendix 4). The contractors associated with the Project at any one time will be determined by the particular work that needs to be done; a wide range of experts will contribute to the Project over time. On occasion, directed or sole-source contracts will be let (Appendix 4), but typically work will be subject to an open and fully competitive process.

The science managers are responsible for implementing peer review of the Science Program and its products. This process ensures that the work meets standards of scientific rigor. Most large restoration programs incorporate independent review panels, comprised of qualified individuals who are not participants in the long-term monitoring and research studies. These panels include peer reviewers and science advisors, and also protocol evaluation panels to assess the quality of research, monitoring, and science being conducted through the adaptive management program; they provide recommendations for further improvement. The entire Project, including the science and decision-making arms, will undergo review by experts external to the Project on a regular basis. For the first few years, the Project may be reviewed every other year. After that, 5-year reviews may be adequate.

In addition to peer review, monitoring and research will also require review and permitting by the landowners (DFG and FWS) and, in some cases, by regulatory agencies, such as the FWS Endangered Species Office. Work done through universities will require authorizations from human and animal care committees, when appropriate.

Stakeholder Forum and Local Work Groups. Substantial public involvement is essential for support and stewardship of long-term restoration projects and is one of the four functions of the AMP institutional structure. The Stakeholder Forum and Work Groups are designed to provide ongoing, publicly-derived input to the PMT on major components of the restoration plan and adaptive management actions. This input will be used by the PMT to help guide management direction. The Stakeholder Forum will remain as it was constituted in the planning process, composed of approximately 30 core stakeholders with demonstrated, ongoing interest in South Bay ecosystem restoration, representing the following sectors:

- Local Business and Adjacent Landowners;
- Environmental Organizations;
- Public Access /Recreation Interests;
- Public Infrastructure;
- Community Advocates and Institutions;
- Flood Management;
- Public Works/Public Health; and
- Local or State Elected Officials.

Local government staff and elected officials will be invited to join the Stakeholder Forum. Each year, one meeting of the Forum will be dedicated to an Annual Report from the PMT focusing on project accomplishments, progress toward Project Objectives, updates to restoration targets and triggers, lessons learned, progress on local projects, and plans for the upcoming year. Additional Stakeholder Forum meetings will be held as needed for topics such as the Shoreline Study progress, implementation of the Adaptive Management Plan, significant scientific findings, and when unusual monitoring activity results in a management trigger.

Local Work Groups, associated with each pond complex, will be established and will meet two to three times per year at Project milestones. Additional Work Group meetings may be held as needed. These Work Groups will be open to everyone, including Stakeholder Forum members, with a special emphasis on inclusion of local elected officials or staff. The local land managers and flood control districts will participate and a State Coastal Conservancy representative will chair the meetings. The Project Management Team will also make use of other existing groups. For example, the Lower Alameda Creek Task Force could be asked for feedback on plans for the southern half of Eden Landing, and the Alviso Water Task Force could provide feedback regarding the areas around Alviso.

A significant, but often overlooked component of adaptive management is social learning, in which all players interact with and learn from each other (Van Cleve, et al. 2003). One obvious avenue for social learning is educating the public about the science and policy of the restoration project (Parson and Clark, 1995). Providing Stakeholders with clear summaries of monitoring and research information will help them understand the ecosystem. Social learning also means that the PMT will respond to concerns voiced by the diverse population comprising the South Bay area, and will incorporate transparent and genuine ways of responding to public comments. Sincere efforts by the PMT to listen and respond to concerns raised by the

Stakeholder Forum, Local Work Groups, and individuals and groups not already involved in the Project will help to build trust and provide a solid foundation for decision-making over the 50-year lifespan of the Project.

Information Management Staff. This group will be responsible for data storage and access, including monitoring and/or GIS data and is the link among the data collection groups, the PMT, and the public. The Information Management Staff will work with the Science Program managers to provide data and reports to the PMT and to ensure that data from monitoring efforts are made widely available. This group will organize and maintain an Information Repository, which will store and archive the Project's documentation, including decisions, agendas, reports, and monitoring data. To support the Project's mission to distribute information, the Information Management Staff will manage the Project's website. This group will coordinate with other agencies and organizations involved in data management in the South Bay. The Information Repository and management systems should include:

- clear data and metadata transfer and input policies and standards;
- policies and procedures for data validation;
- mechanisms to ensure data integrity and security;
- policies and procedures for public information access and outreach;
- database software and database models to facilitate storage and retrieval; and
- tools to facilitate basic data analysis as determined by the PMT.

Resources in the Information Repository will be organized in a manner that makes clear the level to which the data have been analyzed. One archive approach might categorize information as follows:

- general information—press releases, fact sheets, information summaries, abstracts;
- publications—reports, agreements, printed materials; peer-reviewed articles;
- status and trends—high-level interpretations, graphs, charts;
- maps—watershed profiles, bay atlas; and
- raw data—real-time monitoring, preliminary studies, raw monitoring data.

Documentation would make clear that raw data are high-quality, but have not been interpreted; they will not generally be useful to the public or PMT. One exception is real-time monitoring data, which come from systems that provide easily understood data for immediate dissemination on a website. Data converted to maps they are more easily interpreted and some of this graphical work may be conducted by the Information Management Staff. Complete analysis occurs at the publication level in reports generated by the Science Program. General information is the most accessible level, providing information from previous levels in forms that are clear and understandable to the public and the PMT.

C. Interactive Processes

The Project participants will use a number of methods to coordinate their activities to provide information in a timely manner to the PMT.

Direct Connections. The PMT and Science Program will be integrated, as the Lead Scientist and Monitoring Director will be members of the PMT. When appropriate, regulatory representatives will attend PMT meetings to have direct dialog on regulatory issues. The PMT members, including the science directors, will attend Stakeholder Forum and Work Group meetings to give updates on Project progress and listen to public input. The Science Program managers and other PMT members will work directly with the Information Management Staff to design data storage, analysis, and display methods, as well as public outreach tools.

Reports and Meetings. At a yearly meeting, the PMT will present the Project's progress to the Stakeholder Forum and Local Work Groups and will solicit comments on management directions, when appropriate. This information will go into a yearly report to the public. It is also the task of the PMT to generate reports, as required, by regulatory agencies such as the Regional Water Quality Control Board and the FWS Endangered Species Program.

Science Program reports, for use by the PMT in developing management direction, will be produced through a transparent peer-review process. Specifically, approximately once per year, the Science Program will ensure that summary reports presenting and interpreting the information generated since the last review are generated. Reports will make recommendations for future applied studies, monitoring, and management. At a Project meeting separate from the one between the PMT and the Stakeholders, contractors and the Science Program managers, to the extent they are involved, will present their findings and management interpretations to a peer-review panel. The Stakeholders and Work Group members will be encouraged to attend this meeting. This mechanism accomplishes peer review of Science Program products while providing transparency. It allows the public to learn about the work the Project has produced and the hear comment from peer-reviewers on that work.

Perhaps once or twice a year the Lead Scientist will convene a "science consortium", bringing together researchers and institutions to encourage them to undertake research in the South Bay that the Project cannot fund. These consortiums would inform scientists about research opportunities relevant to the Project, encourage scientific collaborations, and identify ways that the Project might assist researchers, such as by providing letters of support or helping to secure permits. Every two to three years the Science Program managers will host a Science Symposium designed to highlight results of current research relevant to the Project.

Some of the data for the Science Program reports will come from the Information Management Staff, which will provide a yearly summary, and perhaps more frequent mini-reports, describing the data available (old and new), giving basic analysis of monitoring and research data, and reporting on public outreach systems and outcomes.

Stakeholders and other members of the public will have multiple opportunities during the year to provide feedback to the PMT. In addition to the PMT and Science Program meetings described above, the Stakeholder Forum will meet additional times during the year, as required. Additional meetings will occur only if an issue requires comment from the full range of

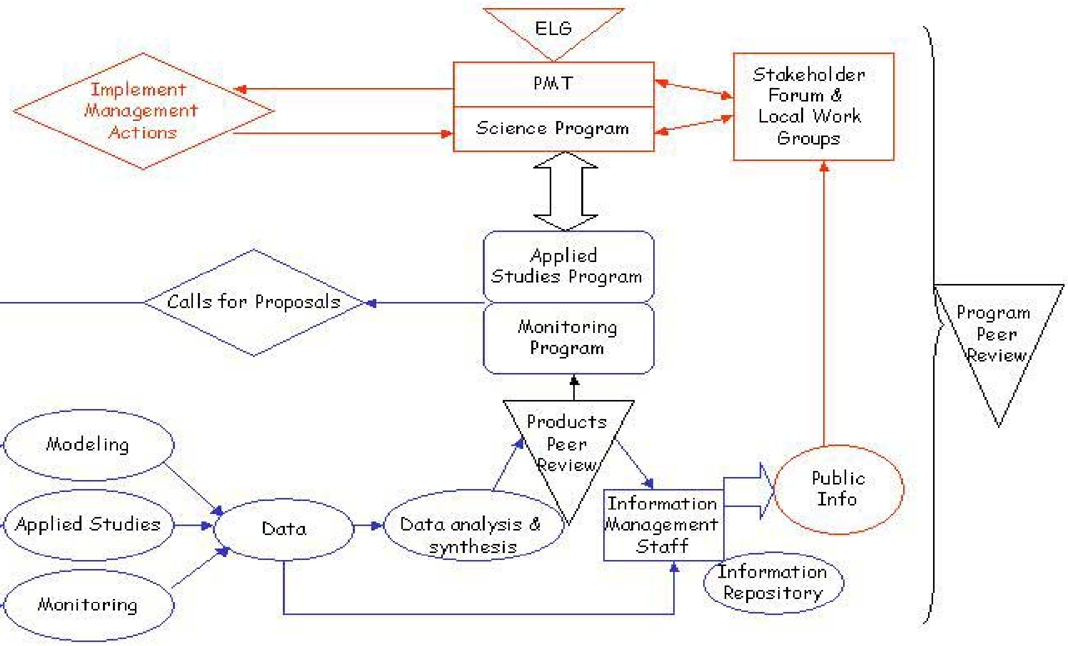
Stakeholders. The Project managers expect Local Work Groups to meet more frequently than the full Forum during the year to talk with the PMT about local Project activities.

Activity Cycles. The public will be informed of Project activities, such as management actions related to management triggers, and invited to provide input, when possible. As described in Part 3, there will be rapid- and slow-response processes in response to management triggers. For slow-response management triggers, the Stakeholders will be involved, through meetings, reports, and email, before management actions are taken. However, for rapid-response management triggers and unanticipated events, decisions and actions will need to occur quickly. The PMT will have developed a suite of responses, in advance, to deal with such issues and typically actions will be chosen from this suite. For other triggers, such as those associated with listed species, the management actions will be prescribed in advance by the regulatory agencies. Stakeholders will be informed through the Project website and email alerts when the PMT has taken rapid action on a trigger. Stakeholders will have the opportunity to discuss what occurred and provide input to the PMT on potential changes to future situations. When a suite of actions is predetermined, the Stakeholders will be informed of these and will be involved in their development, to the extent possible.

Within the Science Program, there are also different cycles of activity. Yearly, the science managers will determine whether the data collected are adequate to meet the Project's monitoring needs and will refine the Project's applied studies and monitoring needs. Calls for proposals for applied studies and monitoring will typically be posted on a yearly basis. Also yearly, the Science Program managers will evaluate the monitoring, modeling, and applied studies reports from the contractors to determine progress toward restoration targets. Applied studies and overall monitoring findings will be evaluated and reported approximately yearly at the public Science Program meeting, as described above. Figure 11 shows how data collection and decision-making are integrated.

Some monitoring data must be screened more regularly to assess whether management triggers are reached. To provide information in a timely manner to the PMT, the Monitoring Director will have an evaluation schedule for different parameters. For example, dissolved oxygen data may need to be reviewed monthly for problems, bird data may need evaluation seasonally, and sediment changes data every 5 years. The data collectors, Monitoring Director, and appropriate PMT members will review the data as required. If warranted, the Monitoring Director and Lead Scientist will meet with the rest of the PMT to determine whether a management trigger has been reached.

FIGURE 11. Adaptive Management Data Collection Processes



REFERENCES CITED

Callaway, J. C., G. Sullivan, J. S. Desmond, G. D. Williams, and J. B. Zedler. 2001. Assessment and monitoring. Pages 271-335 *in* J. B. Zedler (ed.). Handbook for Restoring Tidal Wetlands. *CRC Press*. Boca Raton, Florida.

Carney, K.M. and W.J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68-79.

Collins, J.N. and R.M. Grossinger. 2004. Synthesis of Scientific Knowledge Concerning Estuarine Landscapes and Related Habitats of the South Bay Ecosystem. Technical report of the South Bay Salt Pond Restoration Project. San Francisco Estuary Institute, Oakland, CA. [online] URL: http://www.southbayrestoration.org/Science.html

Comprehensive Everglades Restoration Plan (CERP). 2004. Development of the CERP Monitoring Plan and Adaptive Management Program. CERP Monitoring and Assessment Plan, Part 1. [online] URL: www.evergladesplan.org/pm/recover/ recover_docs/map/MAP_2.0_Develop.pdf

Davis, J. 2005. Draft Science Synthesis Summary for Issue 7: Predicting Pollutant Effects on the Biological Functioning of the South Bay. Technical report of the South Bay Salt Pond Restoration Project. San Francisco Estuary Institute, Oakland, CA. [online] URL: http://www.southbayrestoration.org/Science.html

Flanigan, F. H. 2004. Science Communication and Outreach in the Chesapeake Bay Watershed. Alliance for the Chesapeake Bay. Presentation at First National Conference on Ecosystem Restoration. December 6-10, 2004. Orlando, Florida.

Glen Canyon Dam Adaptive Management Program. Strategic Plan. 2001. New Final Draft Strategic Plan. [online] URL: www.usbr.gov/uc/envprog/amp/pdfs/sp_final.pdf

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U. S. Environmental Protection Agency, San Francisco, Calif., and San Francisco Bay Regional Water Quality Control Board, Oakland, CA. 209 pp. and appendices.

Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life Histories and Environmental Requirements of Key Plants, Fish, and Wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P. R. Olofson, ed. San Francisco Bay Regional Water Quality Control Board, Oakland, CA. 407 pp.

Gunderson, L., C.S. Holling, and S. S. Light. 1995. Barriers and Bridges to Renewal of Ecosystems and Institutions. Columbia University Press, New York, New York, USA.

Holling, C.S. 1978. Adaptive Environmental Assessment and Management. John Wiley and Sons. London, United Kingdom.

Jacobson, C. 2003. Introduction to Adaptive Management. PhD dissertation. (Online) URL: http://student.lincoln.ac.nz/am-links/am-intro.html

Josselyn, M. 1983. The Ecology of San Francisco Tidal Marshes: A Community Profile. U.S. Fish and Wildlife Service FWS/OBS-83/23. 102 pp.

Life Science Inc. 2003a. South Bay Salt Ponds Initial Stewardship Plan, June 2003. Woodland, CA. 251 pp. [online] URL: http://www.southbayrestoration.org/Documents.html

Life Science Inc. 2003b. South Bay Salt Ponds Initial Stewardship Plan - Environmental impact report/environmental impact statement, December 2003. Woodland, CA. 437 pp. http://www.southbayrestoration.org/Documents.html

Light, S.S. and K. Blann. 2001. Adaptive Management and the Kissimmee River Restoration Project (unpublished manuscript). Implications of Kissimee River Restoration. Unpublished manuscript prepared for the Committee on Restoration of the Greater Everglades Ecosystem. [online] URL:www.adaptivemanagement.net/abstracts.htm

National Research Council. 1992. Restoration of Aquatic Ecosystems. National Academies Press, Washington, DC. 552 pp.

National Research Council. 2003. Adaptive Monitoring and Assessment for the Comprehensive Everglades Restoration Plan. National Academies Press, Washington, DC. 111 pp.

National Science Panel. 2005. South Bay Salt Ponds Charette: A National Science Panel Report. South Bay Salt Pond Restoration Project Meeting, February 27-28, 2005. 30 pp.

Neuman, K.K. 2005. Western Snowy Plover. Unpublished Report to the State Coastal Conservancy, Oakland, California.

Orr, M., S. Crooks, and P. B. Williams. 2003. Will Restored Tidal Marshes Be Sustainable? *San Francisco Estuary and Watershed Science* 1(1) Art. 5. [online] URL: www.doaj.org/openurl?genre=journal&issn=15462366&volume=1&issue=1&date=2003

Parson, E. A., and W. C. Clark. 1995. Sustainable development as social learning: theoretical perspectives and practical challenges for the design of a research program. Pages 428-460 *in* L. H. Gunderson, C. S. Holling, and S. S. Light, editors. *Barriers and bridges to the renewal of ecosystems and institutions.* Columbia University Press, New York, New York, USA.

Philip Williams & Associates, Ltd. (PWA), and P. M. Faber. 2004. *Design Guidelines for Tidal Wetland Restoration in San Francisco Bay*. The Bay Institute and California State Coastal Conservancy, Oakland, CA. 83 pp. San Francisco Estuary Institute. 1998. The San Francisco Bay Area EcoAtlas. Oakland, CA. [online] URL: http://www.sfei.org/ecoatlas/index.html

Schoellhamer, D., J. Lacy, N. Ganju, G. Shellenbarger, and M. Lionberger. 2005. Draft Science Synthesis for Issue 2. Sediment Management: Creating Desired Habitat while Preserving Existing Habitat. Technical Report of the South Bay Salt Pond Restoration Project. State Coastal Conservancy, Oakland, California. [online] URL: http://www.southbayrestoration.org/Science.html

Siegel, S. W., and P. A. M. Bachand. 2002. Feasibility Analysis of South Bay Salt Pond Restoration, San Francisco Estuary, California. Wetlands and Water Resources, San Rafael, CA. 228 pp.

Society of Wetland Scientists. 2003. Position Paper on Performance Standards for Wetland Restoration and Creation. Wetland Concerns Committee, Society of Wetland Scientists. [online] URL: http://www.sws.org/wetlandconcerns/Performance.html. Retrieved on March 6, 2003.

South Bay Salt Pond Restoration Project EIS/R. 2007. Prepared by EDAW, Philip Williams and Associates, Ltd., H.T. Harvey and Associates, Brown and Caldwell, and Geomatrix. Submitted to U.S. Fish and Wildlife Service and California Department of Fish and Game.

Taylor, B., L. Kremsater and R. Ellis. 1997. Adaptive Management of Forests in British Columbia. BC Ministry of Forests, Forest Practices Branch, Victoria BC.

Trivedi, D. 2005. Science Synthesis for Key Science Issue 10: Minimizing The Negative Ecosystem Effects of Infrastructure Related Effects. Technical Report of the South Bay Salt Pond Restoration Project. State Coastal Conservancy, Oakland, California. [online] URL: http://www.southbayrestoration.org/Science.html

Trulio, L.A. 2005. *Science Synthesis for Issue 9*: Understanding the Effects of Public Access and Recreation on Wildlife and their Habitats in the Restoration Project Area. Technical Report of the South Bay Salt Pond Restoration Project. State Coastal Conservancy, Oakland, California. [online] URL: http://www.southbayrestoration.org/Science.html

Trulio, L. A., J. C. Callaway, E. S. Gross, J. R. Lacy, F. H. Nichols, and J. Y. Takekawa. 2004. *South Bay Salt Pond Restoration Project Conceptual Models*. Unpublished Report to the State Coastal Conservancy, Oakland, California. 96 pp.

Van Cleve, F. Brie, C. Simenstad, F. Goetz, and T. Mumford. 2003. Application of "Best Available Science" in Ecosystem Restoration: Lessons Learned From Large-Scale Restoration

Efforts in the U.S. Puget Sound Nearshore Ecosystem Restoration Project, Nearshore Science Team. [online] URL: sal.ocean.washington.edu/ nst/public/products/Lessons_Learned.htm

Walters, C. 1997. Challenges in Adaptive Management of Riparian and Coastal Ecosystems. *Conservation Ecology* 1(2):1. [online] URL: http://www.consecol.org/vol1/iss2/art1/

Walters, C. and C.S. Holling. 1990. Large-Scale Management Experiments and Learning by Doing. *Ecology* 71:2060-2068.

Warnock, N. 2005. Synthesis of Scientific Knowledge for Managing Salt Ponds to Protect Bird Populations. Technical Report of the South Bay Salt Pond Restoration Project. State Coastal Conservancy, Oakland, California. [online] URL: http://www.southbayrestoration.org/Science.html

Warnock, N., G. W. Page, T. D. Ruhlen, N. Nur, J. Y. Takekawa, and J. T. Hanson. 2002. Management and Conservation of San Francisco Bay Salt Ponds: Effects of Pond Salinity, Area, Tide, and Season on Pacific Flyway Waterbirds. *Waterbirds* 25: 79-92.

Woodward, F.I. 1994. How Many Species are Required for a Functional Ecosystem? Pg. 271-292. In Schulze, E.-D. and H.A. Mooney, eds. Biodiversity and Ecosystem Function. Springer-Verlag, New York, New York.

APPENDIX 1: Descriptions for Applied Studies Design

In this Appendix, the Science Team members give detailed guidance to Project Managers and future researchers on potential hypotheses and study designs that could be used to address the Applied Study questions listed in Table 2. These descriptions should serve as a starting point for researchers preparing proposals in response to calls for proposals or designing research for the Project that they will fund through means separate from the Project. Descriptions for Applied Study Questions 6 and 7, on bird use of saline habitats and islands, are given in Appendix 5. Descriptions for Applied Studies 9 (California clapper rail use of tidal habitats), 13 (pond management effects), and 14 (non-native *Spartina* effects) are not included as questions 9 and 13 did not have Science Syntheses to draw upon and research approaches to question 14 will be dependent on other agencies, such as the Invasive *Spartina* Project.

Applied Studies Question 1: Will sediment accretion in restored tidal areas be adequate to create and to support emergent tidal marsh ecosystems within the 50-yr project time frame?
David Schoellhamer, Science Team Member

Background/Rationale

Project objective 1 is to create, restore, or enhance habitats of sufficient size, function, and appropriate structure to promote restoration and support increased abundance and diversity of native species in South San Francisco Bay. Desired species primarily utilize either tidally-influenced aquatic habitats or vegetated marsh habitats. In order to create these habitats, the Project must introduce tidal action to existing nontidal submerged salt ponds. The levees around the ponds will be breached to connect the ponds to the estuary and allow the water level in the ponds to vary with the tides. Pond volume below mean tide level, the approximate elevation needed for vegetation colonization, is 31 to 33 million m^3, over 99% within the Alviso ponds. The five most subsided ponds contain one-half of this volume. Thus, the bed elevation of subsided ponds must be raised before it can be colonized by marsh vegetation. Natural deposition of sediment is the most cost effective method to accomplish this. Placement of dredged sediment is a faster alternative but increases costs and regulatory impediments. Once established, vegetation helps the marsh develop by trapping additional sediment and providing organic material. As land subsides and sea level rises, sedimentation is needed to maintain the elevation of the marsh relative to sea level. The net rate of sedimentation will determine whether and when some project objectives will be met.

Natural sedimentation within the ponds will be dependent upon:

- Sediment supply from local tributaries and Bay waters.
- Transport of sediment from the Bay and sloughs into the ponds by tidal currents.
- Deposition and retention of sediment in the ponds.

The rate of sediment supply from local tributaries and Bay waters to the ponds and sediment demand of restored ponds must be known to answer the question. USGS has measured the existing bathymetry of the ponds, so the highest priorities are to gain a better understanding of sediment supply and deposition and retention within restored ponds. Of immediate importance is to continue tributary sediment load measurements because annual variability is large and recent data are scant which can lead to inaccurate estimates of sediment supply. The null hypothesis is that sediment supply is not sufficient to create and to support emergent tidal marsh ecosystems within the 50-year project time frame.

Applied Study Design Concepts
The goal of these studies should be to develop predictive capabilities that can be used by the Project for evaluating how far up the adaptive management staircase the project can go and the likelihood of success of future restoration phases. This would essentially improve upon the South Bay Geomorphic Assessment undertaken at the beginning of the Project. The following major elements are likely to be needed:
1) Measurement of sediment supply from the watershed and Bay waters to the Project area.
2) Analysis of measurements to develop simple algorithms of how precipitation, tributary discharge, tides, and wind affect sediment supply. Estimated cost for the USGS to operate 6 riverine stations and 3 tidal stations and analyze the data is $750,000 per year.
3) Measurement of accretion and vegetation colonization in ponds restored by the ISP and early Project phases.
4) Analysis of pond measurements to develop algorithms or models of deposition and vegetation colonization of restored ponds. Estimated ballpark costs of items 3 and 4 ranges from $100,000 for a graduate student or post doc, involvement of advising professor, and supplies, up to $300,000 per year for a larger University or agency effort.
5) Development of numerical models of watershed sediment supply, Bay sediment supply, and restored pond evolution. A key component is developing hydrologic and climate scenarios to drive the models. The models would use the algorithms from steps 2 and 4 and would be calibrated and verified by hindcasting pond evolution using data collected in steps 1 and 3. Estimated ballpark cost is $200,000 per year for 3 graduate students and involvement of advising professor up to $410,000 per year for a larger University, agency, or 2005 ECOFORE proposal effort.

Because of uncertainties in the models and in developing future hydrologic and climate scenarios, the Project may find that comparing the difference in model results between different restoration scenarios is more useful than evaluating the result of a single restoration scenario.

Sediment supply from tributaries is affected by watershed hydrology and sediment supply from South Bay is affected by suspended sediment concentrations and salinity in Central Bay, which are determined by flows from the Central Valley. Thus, the spatial scale of the study is the watershed of San Francisco Bay and Bay waters. It may be possible to represent processes outside of the Project area by parameterization, surrogates, or algorithms.

Measurements of sediment supply, pond accretion, and vegetation colonization are needed to develop robust predictive models and should be undertaken during the ISP and phase 1. As more data and analyses of the data become available over years to decades, the accuracy of models will improve.

Management Response
Progress up the adaptive management staircase can continue if sediment supply is sufficient for colonization of desired vegetation. If sediment supply is insufficient, then use of fill, perhaps dredged material, is required to continue progress up the staircase. Another alternative may be to alter design of restored ponds to increase deposition. Otherwise progress up the staircase is impossible and unrestored ponds will have to be operated as managed ponds. If results are inconclusive, managers will have to decide whether to stop restoration or to continue restoration and monitor and evaluate pond evolution to determine if an additional restoration phase is desired.

Applied Studies Question 2: Will sediment movement into restored tidal areas significantly reduce habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance) in the South Bay?
David Schoellhamer, Science Team Member

Background/Rationale
Although restoration actions are designed to increase habitat quantity and quality, they also have the potential to destroy valuable existing habitat. For example, one effect of breaching a pond to a tidal slough or Bay is to increase the tidal prism of South Bay and the slough. Tidal prism is the change in water volume between low and high tide for a given region. Restoration essentially undoes what the original diking of tidal marsh did: reduce tidal prism and allow remaining tidal channels to fill with sediment. If tides were reintroduced to an area equal to the area of the Alviso ponds (9.4 km^2), the tidal prism south of the San Mateo Bridge would increase by about 10%. When the tidal prism increases, tidal velocities must increase to accommodate the new prism. Increased velocity can cause erosion of existing marsh or tidal flats and scour of subtidal channels. Marsh and tidal flats are critical habitat for shorebirds and waterfowl, are integral in nutrient cycling and food web dynamics, and protect the shoreline from erosion. Indirect impacts from restoration actions are also possible, including changing plankton dynamics through changes in vertical and horizontal mixing in the water column.

For geomorphic responses, the null hypothesis is that restoration does not alter the geomorphology of existing South Bay tidal habitats and adjacent subtidal channels. Studies would measure change of the area and characteristics of existing habitats.

For ecological responses, the null hypothesis is that restoration does not alter the ecological functions of existing South Bay tidal and subtidal habitats. Studies would measure change in the diversity and abundance of species that use these habitats in South Bay.

Applied Study Design Concepts
Geomorphic studies would measure change of the area of tidal marsh in the slough providing tidal connection to restored ponds and in South Bay, change of slough channel bathymetry, change of mudflat bathymetry in South Bay, and change of subtidal bathymetry in South Bay. Geomorphic response to breaching can not be accurately predicted so studies will require flexibility. The most likely scour location is at or adjacent to the breach. Scour may start at the breach and progress through the slough toward the Bay or the slough and mudflats may scour uniformly. It may take years to decades for a new dynamic equilibrium to emerge or scour may never be measurable away from the breach. A cause and effect relation may be difficult to establish between restoration and scour far from a breach, especially if part of the path to the breach is not scouring. In addition to scour, coarsening of bed material and deposition where currents are unable to support increased sediment in suspension are possible. Initially, bathymetry and bed material size should be measured before breaching and annually. Frequency and specific location of measurements can be refined in response to initial data analysis. Recent LIDAR and bathymetry surveys cost the Project $558,000, so with analysis the estimated cost is $650,000 to $750,000 per survey.

The geomorphic studies would provide a measure of the transformation of existing habitat caused by restoration. The effect of habitat change on ecological function would be determined by studies of species that use these habitats and of other functions of interest, e.g., nutrient cycling. Use of habitats should be measured before breaching and if a habitat is being lost to determine if density increases or remains constant. Species that utilize habitats that are likely to diminish or are diminishing as well as target resident species should be the priority for measurement. Establishing cause and effect will probably be more difficult than for geomorphic studies. Measurements at control sites not affected by restoration will be necessary.

Habitat quality may also be affected by changes in geomorphology and suspended sediment concentrations. For example, a habitat quality change not necessarily indicated by geomorphic studies are increased vertical and horizontal mixing in South Bay caused by increased tidal prism and decreased turbidity. Phytoplankton dynamics in South Bay are dependent on mixing; increased vertical mixing would remove them from the photic zone and expose them to benthic grazing and increased horizontal mixing would transport more phytoplankton from shallow water where there is net production to deeper channels where there is a net loss of phytoplankton. Restoration areas are sediment sinks that may reduce turbidity and increase the depth of the photic zone. Studies of mixing and plankton production in areas with and without breaches or before and after breaching would be appropriate. Estimated ballpark costs range from $100,000 per year for a graduate student or post doc, involvement of advising professor, and supplies, up to $1,000,000 for a large University or agency study, depending on the scope.

Management Response

Progress up the adaptive management staircase can continue if the null hypotheses are upheld. If the null hypotheses are refuted, possible management responses are to:

- Evaluate whether the Project causes a net loss of habitat or whether local loss is offset by habitat gain elsewhere.
- Place dredged materials to accelerate restoration and reduce new tidal prism
- Place dredged materials to maintain mudflats
- Time breaches (seasonal, wet years) for maximum initial deposition
- Phased breaches to increase tidal prism more slowly
- Locate breaches to minimize damage to sloughs most susceptible to erosion
- Limit additional tidal prism by keeping ponds isolated or developing muted tidal ponds
- Construct temporary or permanent barriers to control which channels have increased tidal prism
- Connect adjacent sloughs to create a zone of flow convergence and sediment deposition
- Slow or stop progress up the staircase

If results are inconclusive, managers will have to decide whether to stop restoration or to continue restoration and monitor and evaluate habitat evolution to determine if an additional restoration phase is desired. Given that the geomorphic and ecological response may take decades, this is a likely outcome.

Applied Studies Question 3: Flood Hazard Uncertainty (part of Sediment Dynamics)

Dilip Trivedi, South Bay Salt Pond Restoration Project, Science Team Member

Introduction

The Science Team identified three Applied Studies questions to address Sediment Dynamics, a Key Uncertainty in achieving the Project Objectives for the South Bay Salt Pond Restoration Project. One primary Project Objective (PO# 2) is to *"Maintain Or Improve Existing Levels Of Flood Protection In The South Bay Area."* To achieve this, we must first identify the existing level of flood protection, and then analyze post-restoration conditions to assess the effects of the project. Since the primary metric of flood hazard is elevation of water levels in the vicinity, predictions of future water levels is necessary. Both, short-term as well as long-term, water levels need to be determined to assess flood hazard potential.

The specific uncertainty, as developed by the Science Team (Applied Studies Question #3), along with a brief explanation of the importance, is described as follows:

> ***Will restoration activities always result in a net decrease in flood hazard ?*** *Increased tidal prism will scour slough channels within a relatively short time frame (months to years) and reduce flood hazard. Changes in tidal elevations and prism in sloughs occurring over months to years may potentially increase flood hazard.*

Background/Rationale

The restoration project envisions opening up some of the diked salt ponds to tidal action. This implies that the levee along the landward edge of those salt ponds will be improved/rehabilitated to sustain tidal as well as wind-induced wave action, such that flood hazard to local communities will not increase. The subject of this Applied Studies discussion is flood hazard resulting from changes in flow within the sloughs and channels which connect to the Bay through the project area. It is important to quantify the impacts of the restoration project on tidal hydrology and water quality in these lower reaches of the creeks. Both, short- and long-term changes need to be considered because the creeks will most likely have a delayed morphologic response to significant changes in tidal prism such as those expected from the restoration project.

Most of the creeks in the project area offer just enough conveyance capacity to convey the design flood flows (100-year in most cases). This was documented in earlier reports (Moffatt & Nichol 2003a, SCVWD 2002). Some creeks, which do not offer this protection, are being modified to contain the design flood flows and the projects are in various stages of development. Changes in tidal water levels in these creeks, even minor, will change the amount of conveyance and may affect the level of flood protection to adjacent communities. Since water levels in the vicinity are a function of fluvial flows from upstream watersheds, astronomical tides, bathymetry, and bed characteristics, each of these elements need to be known for existing as well as future conditions.

<u>Uncertainties</u>

The Project Key Issues document authored by the Science Team had already recognized that the following questions needed to be answered to assess the hydrological impacts of the restoration project:

- what is the hydrology and current pattern in the South Bay as they exist today, and how have they changed over time ? ;
- how will South Bay hydrology change over 50 years in response to human activities and natural processes ? ;
- how will the hydrology in ponds, sloughs and South Bay react to natural changes, as well as human-induced changes (such as ISP, restoration and other changes), over the next 50 years ?

Some of this is already being conducted as part of the environmental review phase. The flood hazard related uncertainties are tied in to hydrological modifications that will occur as a result of the restoration project, primarily due to the combination of fluvial flows and tidal stage. Moving the edge of the Bay farther landward (upstream within the local creeks), as envisioned for the restoration project, may affect the hydrology of the creeks and stability of the levees due to higher currents, scour, and changes in "backwater" elevation. Since the restoration will be phased over several years, assessing the impact of each phase, as well as cumulative impact is necessary.

Applied Study Concepts

Determining the backwater effect within the creeks and potential scour at the base of the flood control levees requires analyzing existing and future hydrological conditions. This is a deterministic effort which can be completed utilizing hydraulic models. Simulations should be conducted for all creeks draining through the project area (Coyote Creek, Guadalupe River, Stevens Creek, Mountain View Slough).

Work should be coordinated with local flood control districts which have conducted Flood Insurance Studies. Output from ongoing SBSP model studies will be needed to model flood stages within the creeks. These parameters include future tidal water levels and allowable future channel dimensions to simulate future conditions. Water levels and velocities should be determined for existing and future conditions, with the emphasis being on storm conditions.

For budgeting purposes, this kind of analysis could be performed using models similar to the existing Flood Insurance Studies models. An allowance of about $200,000 may be sufficient to run the different simulations, assuming that channel surveys and model results from the SBSP restoration project hydrodynamic analysis is available.

Management Options

If it is determined that the backwater elevation increases upstream of the pond levees, due to breaches through slough levees, project design features may have to investigate alternatives for breach locations/dimensions. If it is determined that the base of the flood control levees will scour sufficiently to affect the stability of the levees, mitigation schemes may have to be developed to prevent channel headcutting.

Applied Studies Question #4: Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions? Ecosystem changes and effects must be measured and compiled over time to understand the overall implication of South Bay restoration on migratory birds. Some factors that could affect bird numbers are changes in suitable habitat for particular species, disease and predation rates, food availability, and nest competition.
Nils Warnock, PRBO Conservation Science, South Bay Salt Pond Restoration Project Science Team Member

Background/Rationale
The Science Team identified six Applied Studies questions to address Bird Use of Changing Habitats, a key uncertainty in achieving the Project Objectives for the South Bay Salt Pond Restoration Project. One primary Project Objective is to provide adequate habitat to support pre-ISP numbers and diversity of waterbirds using the South Bay while increasing numbers of tidal marsh birds such as California clapper rails that have historically used the Bay.

Bird use of San Francisco Bay, particularly in the South Bay is high. Birds counts on San Francisco Bay from 1964-1966, showed highest densities of birds in salt ponds, followed by tidal flats, open water, and tidal marshes (Bollman and Thelin 1970). Single day counts of waterbirds in the salt ponds during winter months can exceed 200,000 individuals (Harvey *et al.* 1992), and single day counts during peak spring migration have exceeded 200,000 shorebirds in a single salt evaporation pond (Stenzel and Page 1988). Takekawa et al. (2000) reported that the South Bay salt ponds supported up to 76,000 waterfowl (up to 27% of the Bay's total waterfowl population) including 90% of the Bay's Northern Shovelers, 67% of the Ruddy Ducks, and 17% of the Canvasbacks. Depending on the year, 5-13% of the federally threatened U.S. Snowy Plover Pacific Coast population breeds at San Francisco Bay, mainly in the South Bay salt ponds (Page *et al.* 1991, Strong et al. 2004). In some years, >20% (1,500 – 2,500 pairs) of the Pacific Coast Forster's Terns may nest in the salt ponds of the South Bay (Strong et al. 2004b).

However, various modeling efforts and expert opinion have suggested that there is the potential for significant declines in some bird populations, particularly waterbirds, if significant amounts of salt pond habitat are converted to vegetated tidal marsh habitat (Takekawa et al. 2000, Stralberg et al. 2003). For instance, Takekawa et al. (2000) estimated that if 50% of the South Bay's salt ponds were converted to tidal marsh, that 15% of the 76,000 waterfowl that use those salt ponds could be lost. Despite the documented importance of San Francisco Bay salt ponds to populations of Pacific Flyway waterbirds, few guidelines exist for state and federal wildlife agencies on how to actively manage a significantly smaller amount of salt pond habitat in the South Bay than currently exists to achieve the maximum abundance and diversity of birds using the habitat while keeping maintenance costs and efforts to a minimum. Answers to these questions rely in part on understanding bird use patterns in and around the salt ponds.

This description gives background to one (Applied Study Question #4) of the six key applied studies identified for the key uncertainty, Bird Use of Changing Habitat - "Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions?"

Study Design Concepts

Applied studies to this key uncertainty will primarily be addressed in the other five applied studies questions (ASQ #5-9):

5) Will shallowly flooded ponds or ponds constructed with island or furrows provide breeding habitat to support sustainable densities of snowy plovers while providing foraging and roosting habitat for migratory shorebirds compared to existing ponds not managed in this manner?
6) Will ponds reconfigured and managed to provide target water and salinity levels significantly increase the prey base for, and pond use by waterfowl, shorebirds and phalaropes/grebes compared to existing ponds not managed in this manner?
7) Will ponds that are reconfigured to create large isolated islands for nesting and foraging significantly increase reproductive success for terns and other nesting birds and also increase the numbers and densities of foraging birds over the long term compared to existing ponds not managed in this manner?
8) Will inter-marsh pond and panne habitats in restoring tidal marshes provide habitat for significant numbers of foraging and roosting shorebirds and waterfowl over the long term?

9) How do California clapper rails and/or other key tidal marsh species respond to variations in tidal marsh habitat quality and what are the habitat factors contributing to that response?

Answering AS Questions 5-9 will go a long way in addressing AS Question #4, whether the restoration will be able to maintain and improve the carrying capacity of birds in the South Bay. However, key to answering AS Question #4 will be to having an adequate bird monitoring program in place for the restoration project.

Monitoring bird populations in the South Bay

- Study Population: all bird species using the restoration area
- Study Sites: This monitoring will need to encompass several spatial scales including a) the restoration area, b) the South Bay, and c) San Francisco Bay.
- Parameters Measured: Numbers, species diversity, reproductive success, survival; predicted densities (these densities will be generated from modeling exercises on what numbers and diversity of birds are predicted in different restored habitats)
- Study Design: various monitoring designs depending on parameter being measured; Modeling of predicted bird densities in restored habitats to follow methods established by Stralberg et al. (2003).
- Time Frame for Study: monitoring of restoration area should be conducted monthly for the foreseeable future; efforts should be expanded to South Bay and whole Bay scales at some annual interval (every 1-3 years).
- Estimated Study Cost: Monitoring efforts to be split by various organizations and agencies but critical to compile to a central data base including centralized, periodic synthesis of data. Costs - $100,000-250,000/year

Management Options

The results of this monitoring will provide specific data to land managers and other interested parties on trends and predicted densities of focal bird species in the restored area. These data will be compared with trends of bird populations in the South Bay and the entire Bay. These data will serve as triggers for applied management actions. If targets are not met, specific information gathered from AS questions 5-9, can be used to increase carrying capacity of specific habitats to help species of concern.

Citations

Bollman, F. H., and P. K. Thelin. 1970. Bimonthly bird counts at selected observation points around San Francisco Bay, February 1964 to January 1966. Calif. Fish and Game 56:224-239.

Harvey, T. E., Miller, K. J., Hothem, R. L., Rauzon, M. J., Page, G. W., and Keck, R. A. 1992. Status and trends report on wildlife of the San Francisco Bay Estuary. Prepared by the U.S. Fish and Wildlife Service for the San Francisco Estuary Project. U.S. Environmental Protection Agency, San Francisco, California.

Page, G. W., L. E. Stenzel and W. D. Shuford. 1991. Distribution and abundance of the Snowy Plover on its western North American breeding grounds. Journal of Field Ornithology 62: 245-255.

Stenzel, L. E. and G. W. Page. 1988. Results of the first comprehensive shorebird census of San Francisco and San Pablo bays. Wader Study Group Bulletin 54: 43-48.
Stralberg, D., N. Warnock, N. Nur, H. Spautz and G.W. Page. 2003. Predicting the effects of habitat change on South San Francisco Bay bird communities: an analysis of bird-habitat relationships and evaluation of potential restoration scenarios (Contract # 02-009, Title: Habitat Conversion Model). Final report, California Coastal Conservancy, Oakland, CA
Strong, C. M., L. Spear, T. Ryan, and R. Dakin. 2004. Forster's Tern, Caspian Tern, and California Gull colonies in San Francisco Bay: habitat use, numbers and trends, 1982-2003. Waterbirds 27: 411-423.
Takekawa, J. Y. , G. W. Page, J. M. Alexander, and D. R. Becker. 2000. Waterfowl and shorebirds of the San Francisco Bay estuary. Pages 309-316 *in* Goals project 2000. Baylands ecosystem species and community profiles: life histories and environmental requirements of key plants, fish and wildlife (P. Olofson, Ed.). Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. San Francisco Bay Regional Water Quality Control Board, Oakland, California.
Warnock, N. 2005. Synthesis of Scientific Knowledge for Managing Salt Ponds to Protect Bird Populations. Technical Report of the South Bay Salt Pond Restoration Project. State Coastal Conservancy, Oakland, California. [online] URL: http://www.southbayrestoration.org/Science.html

Applied studies Question 5: Will shallowly flooded ponds or ponds constructed with island or furrows provide breeding habitat to support sustainable densities of snowy plovers while providing foraging and roosting habitat for migratory shorebirds compared to existing ponds not managed in this manner?

Cheryl Strong, San Francisco Bay Bird Observatory, Science Team Member
Caitlin Robinson, San Jose State University, MS Graduate Student
Lynne Trulio, South Bay Salt Pond Restoration Project, Lead Scientist/Science Team Member

Background/Rationale

Project Objective 1 states that the South Bay Salt Pond Restoration Project will maintain current migratory bird species that utilize existing salt ponds and associated structures such as levees. One of the main concerns of the restoration plan is how to maintain the current numbers of migratory and wintering waterbirds that utilize the salt ponds for foraging and roosting within a smaller number of managed ponds. If ponds can be managed specifically for wildlife habitat such as bird use, then less acreage of managed ponds may need to be maintained. This would: 1) allow for more tidal marsh acreage to be restored, 2) minimize the amount of human intervention and maximize the amount of natural processes within the system, and 3) reduce the cost of long-term management in the project area.

San Francisco Bay salt ponds support hundreds of thousands of shorebirds during the winter and migratory months, the largest numbers of which are found on South Bay mudflats and shallow salt ponds (Goals Project 2000). Yet dry salt ponds have also become important nesting habitat for the federally threatened Western Snowy Plover. Plovers require a unique set of habitat characteristics: they lay their eggs on dry or drying salt ponds, and feed on the high concentrations of brine flies that swarm along the edge of these ponds in highly saline water (Goals Project 2000). If a set of ponds could be managed for shorebirds September to March, then for nesting plovers April to August, we could reduce the footprint of ponds necessary to maintain numbers.

To collect reliable information on this question, we recommend testing the following three null hypotheses. These hypotheses for Western Snowy Plovers and migratory shorebirds can be tested together in one carefully designed experiment:

Ho_1: Ponds managed for Western Snowy Plover by lowering water levels in the spring and summer will not increase the plover nesting density and hatching success.

Ho_2: There is no relationship between ponds constructed with islands or furrows and Western Snowy Plover nest site selection.

Ho_3: The same ponds above (Ho_1) will not support the pre-ISP diversity and abundance of shorebirds when flooded during the winter/migrating period.

- Time Frame for Study: At least three years of data are required to detect significant results for all of the hypotheses above. SFBBO will monitor plover nest success (Ho_1) least through 2007. Plover nest site selection (Ho_1) study currently underway in 2006 (C. Robinson under direction of L. Trulio and with SFFBO); data collection expected through summer 2007. Shorebird surveys (Ho_3) are currently conducted bi-monthly by USGS through 2006.
- Ballpark cost estimate: $25,000-50,000/year (not including USGS surveys or maintenance of furrows and islands).
- Study Sites: Ho_1 and Ho_3: Managed ponds: E6A, E6B, E8 E8A and E8X;
- Control ponds: E1C, E4C, E5C, E11, E12 and E14. No ponds have been selected for Ho_2 as of yet, but could include E16B, E15B.

Study Design

Objective 1: Locate snowy plover nests and determine productivity in managed and control ponds. March-August, all snowy plover activity on the pond will be identified to determine foraging and nesting use of the ponds. Surveys will take place approximately once/week and all foraging and nesting birds marked on maps. Nesting birds will be followed as per SFBBO/FWS protocols: nests identified and return visits at approximate 1-2 times/week to determine nest fate.

Objective 2: Locate snowy plover nests and determine productivity in ponds with and without created islands or furrows. March-August, all snowy plover activity on the pond will be identified to determine foraging and nesting use of the ponds. Surveys will take place approximately once/week and all foraging and nesting birds marked on maps. Nesting birds will be followed as per SFBBO/FWS protocols: nests identified and return visits at approximate 1-2 times/week to determine nest fate. All nests will be located with GPS and distance to (or location one) furrow or island will be determined.

Objective 3: Identify shorebird diversity and abundance, and percentage of birds feeding in pond. Using existing survey protocols, ponds will be divided into 250m x 250m grids for mapping in ArcView. All birds will be counted August-April, within 3 hours of high tide, identified to species, determined to be foraging or roosting, and recorded in a grid square. Data will be entered into spreadsheets and added into the grid coverage by abundance. Low water levels must be maintained (5-15 cm) in order to create foraging habitat for small to medium shorebirds. The same ponds will be used as stated in Objective 1. These ponds have been monitored for shorebird use by USGS; these data can be used as "pre-management" data to compare.

Management Responses:
If fewer ponds can support large numbers of wintering/migrating shorebirds as well as successfully nesting plovers, then the PMT can consider movement up the Adaptive Management staircase. Local land managers will need to balance water quality issues with the drying of ponds for the summer months. Pond intakes may need to be closed to prevent flooding of plover nests and/or broods. If this is the case, then these ponds may not be able to reopen to discharge into the bay waters without significant fresh or bay water input after the nesting season has ended. We assume that mammalian predator management will continue in order to help maintain nesting success for plovers. If ponds cannot be managed to successfully maintain habitat for both wintering/migrating shorebirds and nesting plovers, then the Project Management Team will need to reassess the area of dry/seasonal wetlands created within the South Bay landscape before movement up the staircase can be considered.

Citations
Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P.R. Olofson, editor. San Francisco Bay Regional Water Quality Control Board, Oakland, Calif.

Applied Studies Question #8: Will inter-marsh pond and panne habitats in restoring tidal marshes provide habitat for significant numbers of foraging and roosting shorebirds and waterfowl over the long term?
John Takekawa, South Bay Salt Pond Restoration Project, Science Team Member

Background/Rationale
To meet the South Bay Salt Pond Restoration Project goal of "no net loss" of waterbirds, adequate habitat must be available within and outside the project site to meet their needs. As ponds become vegetated and change to marsh, birds that currently use ponds heavily could face a population-limiting decline in suitable habitat. Ponded areas and panne habitats within transitional or mature marshes could provide interim or even long-term habitat for some salt pond species. However, not all species may use inter-marsh and panne habitats equally. Furthermore, because such habitat is likely to be less abundant than existing salt pond habitat, waterbird densities comparable to those on salt ponds would be necessary to have a significant impact on local populations. To determine whether these habitats could supplement pond habitat, we need to know the potential total area of these habitats as well as:

1. What species or foraging guilds most use inter-marsh pond and panne habitat and how does the species composition of these habitats compare to that of salt ponds?
2. What are the mean seasonal densities of birds using inter-marsh pond and panne habitat?

We recommend specific hypotheses or research questions be designed to address these two questions.

Study Design Concept
Both these questions could be addressed with surveys of developing and developed marsh habitats. Bird surveys should use data collection methods similar to those used on salt ponds so that the data are comparable.

- <u>Study Sites</u>: Developed and developing marshes around San Francisco and San Pablo Bays, including Tolay Creek and Napa-Sonoma Marshes pond 2A.
- <u>Parameters Measured</u>: Complete area counts of birds, identified to species and placed within 250-m survey grids. Behavior and microhabitat data recorded.
- <u>Study Design</u>: Complete counts divided by high and low tide at each site.
- <u>Time Frame for Study</u>: At least one year of monthly counts are needed to assess seasonal variation in site use by migratory birds.
- <u>Estimated Study Cost</u>: Dependent upon the number of sites and frequency of monitoring. Two biological science technicians working half to full-time could survey several sites monthly. Ballpark cost estimate: $40,000-$80,000

Management Options
The results of this study will provide important information to land managers on habitat value of inter-marsh ponded areas and panne habitats to waterbirds that currently use salt ponds. This information can be used to assess habitat needs of waterbirds and determine which ponds should be managed as open water areas and at what depth and salinity.

Applied Studies Question 10: *Will increased tidal habitats improve survival, growth and reproduction of native species, especially fish and harbor seals?* The extent to which restoring the dominant tidal marsh habitat will affect native fish, including the steelhead, and harbor seals, who feed on them, is unknown.
Gillian O'Doherty, NOAA Restoration Center, South Bay Salt Pond Restoration Project, Science Team Member

Introduction
One of the Project Objectives (PO) of the South Bay Salt Pond Restoration Project (Project) is to restore and manage habitats for the benefit of species and ecosystem functioning. As part of the Adaptive Management approach the Science Team has identified Key Uncertainties associated with the Project and has formulated Applied Studies Questions to guide research and management. The Science Team identified a single Key Uncertainty/ Applied Studies question for all of the effects of the on non-avian species, specifically identified as estuarine fish, anadromous fish and marine mammals. Restoring tidal access and saltmarsh is predicted to be of net benefit to these species, however human activities, including changes to physical habitat, hydrology, and increased public access, can also have negative effects on species and habitats. The potential impacts of some of the proposed restoration activities on the fish and marine mammals are unknown and must be studied to reduce the uncertainties involved with achieving the PO. The results of these studies will be used to guide actions as the Project progresses.

The following description for the "Effects on Non-Avian Species" Key Uncertainty gives some background as well as general study design concepts and potential management responses to the information generated by the studies.

Although the Applied Studies Question asks about effects on fish survival, growth and reproduction we recommend focusing on diversity and abundance, distribution, growth rates and some limited aspects of reproduction. Effects on survival will be logistically impossible to measure. The Applied Studies Question also refers exclusively to tidal marsh while fish can be expected to benefit from all increased access to tidal areas, marsh channels, bays or shallow open water habitats. Finally the Applied Studies Question refers to estuarine fish, anadromous fish and marine mammals as one but for clarity the effects on estuarine fish, salmonids and marine mammals will be addressed separately.

Estuarine fish

Background/Rationale

Project Objective #1 states that the South Bay Salt Pond Restoration Project will restore and manage habitats for the benefit of species and ecosystem functioning. A primary step in achieving this objective is to identify the effects of the proposed changes to physical habitat of the species that use the area currently and will likely use the restored area. Fish populations in the South Bay are currently not well understood and the impacts of some restoration and management activities are unknown.

The major information gaps relative to the Project are:

1. What native estuarine fish species can be expected to use the project area before, during and after restoration?

2. Will an increase in available tidal habitat increase the abundance of native fish?
3. Will water control structures significantly impact the ability of fish to benefit from managed ponds and muted tidal areas?
4. Is restored habitat of similar value to fish assemblages in terms of growth, feeding and reproduction as reference habitats?
5. Will there be significant negative impacts from Project activities or increased public access?

Study Design Concepts

Some specific ideas on study designs for each question are as follows.

<u>What is the abundance and diversity of native estuarine fish in the project area before, during and after the restoration? Will there be significant negative impacts from Project activities?</u>

- <u>Study Population:</u> Fish populations using the Bay south of the Dumbarton Bridge for all or part of the year, particularly fish that use the marshes and shallow water areas adjacent to the Project.
- <u>Study Sites</u>: Previously restored and undisturbed native marshes; salt ponds; sloughs in the South Bay including Eden Landing 49 acre mitigation marsh, Cogswell Marsh, Faber Tract and Bair Island. Former salt ponds that have been restored to full tidal action and former salt ponds that are accessible only via water control structures.
- <u>Parameters Measured</u>: Seasonal abundance and diversity; length and/or size in order to determine life-stage.
- <u>Study Design</u>: Sampling during the spring, summer and fall in shallow open water, un-vegetated tidal areas and salt marsh channels. Standardized sampling methods need to be

developed from current work for all future work. Ideally, sampling would occur monthly from spring through fall, at least four sampling dates are suggested with emphasis on spring and summer to capture juvenile use of shallow water habitats. In previous studies sampling has occurred in March, June, July and September.
In addition a large amount of data form the Marine Science Institute exists and could be digitized and analyzed to provide a more complete picture of fish assemblages and trends in the South Bay.

- Time Frame for Study: The initial work to establish a baseline is ongoing. Monitoring should continue throughout the Project life.
- Estimated Study Cost: Ballpark cost estimate: $30- 75K/ year for data collection and basic analysis. Cost of digitizing MSI records $10-30K.
- Comments: NOAA Fish Model Study in previously restored marshes is underway as is USGS study of salt ponds and adjacent sloughs. Future studies should build on this work and concentrate on developing standardized sampling methods; identifying areas of special concern, particularly nursery habitats; identifying limiting factors to fish populations and identifying fish assemblages that use discrete habitat types.

Are the growth rates of fish within the project area within normal limits and do they change over time?

- Study Population: Surfperch and native flatfish; other indicator species as identified by USGS and NOAA studies.
- Study Sites: Former salt ponds that have been restored to full tidal action and former salt ponds that are accessible only via water control structures.
- Parameters Measured: length to weight ratio, age.
- Study Design: Collect length and weight data from fish captured in the abundance and diversity studies. Collect otoliths and/or scales from a subset of fish. Data would be compared to literature or previous studies to determine if growth rates were within normal limits. Trends would be monitored
- Time Frame for Study: Starting immediately and continue through the life of the Project.
- Estimated Study Cost: $40K/ year. This study could be carried out by a graduate student with appropriate input.

Is the fecundity of fish within the project area within normal limits and does it change over time?

- Study Population: Surfperch and native flatfish; other indicator species as identified by USGS and NOAA studies.
- Study Sites: Former salt ponds that have been restored to full tidal action and former salt ponds that are accessible only via water control structures..
- Parameters Measured: Fecundity.
- Study Design: Collect target species during spawning periods to determine fecundity. Data would be compared to literature or other studies to determine if fecundity is within normal limits.
- Time Frame for Study: Once yearly sampling for each species indefinitely.
- Estimated Study Cost: $20K/ year. This study could be carried out by a graduate student with appropriate input.

Are the restored areas functioning similarly to natural areas in terms of prey availability?

- Study Population: Surfperch and native flatfish; other indicator species as identified by USGS and NOAA studies.
- Study Sites: 1) Former salt ponds that have been restored to full tidal action within the project area 2) former salt ponds that have been restored to muted tidal action or otherwise utilize water control structures and 3) natural salt marsh areas in SF Bay (or data from literature)
- Parameters Measured: prey composition and prey availability.
- Study Design: Sample invertebrate populations and collect and gut contents from fish captured within the Project area and compare to data from historical salt marsh or long term restoration projects or data from the literature.
- Time Frame for Study: Study would be carried out periodically in newly restored areas and as salt marsh becomes fully vegetated.
- Estimated Study Cost: $25K. This study could be carried out by a graduate student with appropriate input.

What is the effect of increased public access on recreational fishery species?

- Study Population: fish targeted by recreational anglers in the Project Area.
- Study Sites: Fishing areas that are currently legally accessible and new fishing areas that are made accessible during the Project.
- Parameters Measured: Composition and size of catch.
- Study Design: Identify angling spots and conduct creel surveys to determine fishing pressure.
- Time Frame for Study: Creel surveys could be conducted every 2-3 years to track general trends in angler usage and catch.
- Estimated Study Cost: $15K for several study dates.

Management Options

The results of the first study will provide information that can be used to gauge the success of the Project in enhancing native fish species and ecosystem functioning and protecting existing populations. It will provide data on fish use of restored and managed areas and can be used to improve management of these areas to maximize benefits and reduce impacts to fish.

The second, third and fourth studies will provide more data on how various species use the marsh and what kind of benefits the newly restored habitat is providing to native fish species. The final study will provide data on the impact of an increased recreational fishery and may lead to management changes in terms of access.

Salmonids:

Background/Rationale

Steelhead and fall run Chinook salmon are present in the Project area. Threatened steelhead in the Project Area belong to the Central California Coast Distinct Population Segment. An increase in saltmarsh habitat is expected to benefit steelhead and Chinook populations in the area by providing improved estuarine rearing habitat for juveniles and improved migratory conditions for juveniles and adults. However, some management or restoration activities have the potential to negatively affect steelhead populations including water discharges from managed ponds, increased fishing pressure, or incidental take associated with restoration activities and monitoring. The major information gaps relative to the Project are:

1. To what extent will salmonids use the newly restored tidal marsh?

Study Design Concepts.

To what extent will salmonids use the newly restored tidal marsh?

- ❑ Study Population: The steelhead and Chinook salmon that spawn and rear in streams flowing into south San Francisco Bay, which might use the marshes and shallow water areas adjacent to the Project as they migrate to and from the Pacific Ocean.
- ❑ Study Sites: Coyote, Guadalupe, and Alameda creeks.
- ❑ Parameters Measured: Spatial and temporal distribution of salmonids through the Project area.
- ❑ Study Design: Apply acoustic tags to salmonid smolts migrating from tributaries flowing into south San Francisco Bay. The tags should be compatible with those currently being used to tag salmonids in a large multi-agency study to determine the spatial and temporal distribution of juvenile salmonids migrating from the Sacramento River. The dredging community is part of that study and has not only indicated interest in tagging salmonid smolt from south San Francisco Bay, but also has already purchased a large number of monitors which could be used as part of this proposal. By using similar equipment, the movement of the tagged smolts through the Project area and out of the bay could be monitored.
- ❑ Time Frame for Study: The larger salmonid study that is currently underway in the San Francisco Bay region is planned for the spring of 2007-2009. Therefore, if it is essential to tap into their expertise as well as potential access to their equipment, it would not be until the late winter/early spring of 2010. However, if adequate funds could be obtained, then it is possible that a consultant or student (UC Davis is part of the study) could conduct the proposed study, realistically beginning in the spring of 2008. Continued studies would be based on adequate funding.
- ❑ Estimated Study Cost: Each monitor cost ~$1,100 and has a range (radius) of 200 meters. Each tag costs ~$300. Some acoustic tags can be tracked with a mobile tracking unit (boat mounted). Otherwise the monitors are stationary and must be downloaded periodically. The tags that can be placed inside juvenile salmonids have a battery life of ~30-60 days, depending on the ping rate.
- ❑ Comments: Tagging of ESA-listed species will have to be in compliance with Federal and State permits (NMFS and CDFG).

Management Options

This study would be part of a larger, San Francisco Bay wide look at smolt movement and survival. It would allow smolts to be tracked as they moved through the Project area and migrated out of the Bay. It would provide improved data on migration timing and residence time in the Project Area and would improve the ability of managers to plan activities so that they do not negatively impact salmonids.

Marine Mammals:

Background/Rationale

Harbor seals are present throughout the South Bay, which they use to haul out, for reproduction and for feeding. An increase in tidal habitat is expected to benefit harbor seals by increasing the fish populations on which they feed. There is also the potential for restoration activities such as increased public access and changes in tidal prism to negatively impact populations. The major information gaps relative to the Project are:

1. Do restoration activities negatively affect harbor seals from growth, reproduction or survival, in particular use of historical haulouts and pupping areas?

At this point in the Project, we recommend specific hypotheses or research questions be designed to address these two questions.

Study Design Concepts

This work should be coordinated with research conducted on potential public access impacts on harbor seals, which is Applied Studies Question #16. Some specific ideas on study designs for each question are as follows.

<u>Do restoration activities displace harbor seals from feeding, resting or pupping areas?</u>

- ❑ <u>Study Population:</u> Harbor seals in the restoration area or that use adjacent areas to rest, feed or reproduce.
- ❑ <u>Study Sites</u>: Mowry Slough and adjacent pupping and haulout areas
- ❑ <u>Parameters Measured</u>: Numbers of seals using the haulouts for resting. Annual pup production.
- ❑ <u>Study Design</u>: Surveys in the spring and during pupping and rearing seasons.
- ❑ <u>Time Frame for Study</u>: Counts should begin immediately to establish a baseline for population and should continue annually for 10-15 years to monitor potential long-term effects of mercury contamination.
- ❑ <u>Estimated Study Cost</u>: $15K/ year.

Management Options

The results of the study will determine if the Project may be negatively impacting harbor seal numbers through disturbance or changes to the larger ecosystem. Further studies have been proposed as management actions if this is determined to be the case.

Applied Question # 11: Will the scour of Alviso Slough resulting from tidal marsh restoration of associated salt ponds increase the bioavailability of methymercury?
Josh Collins, SFEI Wetland Scientist and Science Team Member

Background and Rationale
The cross-section area of a tidal marsh channel at any point along its length is a function of the volume of water (i.e., the tidal prism) that usually passes that point in the channel during ebb tide (Dyer 1995). If the tidal prism decreases, the channel will get smaller. If the tidal prism increases, the channel will get larger (Dedrick 1979). A change in cross-section area can result from a change in channel width, depth, or both (Collins et al 1987; Coates et al.1989; Leopold et al. 1993).

The reclamation of tidal marshland (i.e., the construction of levees and other structures to isolate the marshland from the tides) represents a loss of tidal prism for the channels that drained the marshlands before they were reclaimed. One result of large-scale reclamation of tidal marshland is therefore a major decrease in the size of the remaining tidal channels. For example, the reclamation of tidal marshland along Alviso Slough in South Bay to create salt ponds caused the slough to narrow and shoal (Dedrick 1993). Conversely, the proposed restoration of these lands as tidal marsh will increase the tidal prism of Alviso Slough, causing it to scour and enlarge. The amount of scour can be predicted from empirically-derived correlations between tidal channel size and tidal prism (Orr and Williams 2002), and from models that relate increases in tidal prism to increases in shear stress against the channel bed, which causes scour.

Sometime during the first quarter of the 20th century, the Guadalupe River was diverted into Alviso Slough (Collins and Grossinger 2005). The Guadalupe watershed contains abundant mercury ore (cinnabar of HgS) that was mined intensively within the watershed as the tidal marshes were being reclaimed. It is likely that the sediments that have accumulated in Alviso Slough during and since the period of mining and reclamation bear large amounts of mercury (Beutel and Abu-Saba 2004).

Mercury (Hg) is dangerously toxic to wildlife and people. The organic form of mercury (methylmercury or MeHg) is an especially powerful neurotoxin that readily accumulates in food chains. Minamata disease, or methyl mercury poisoning, is characterized by peripheral sensory loss, tremors, and loss of memory, hearing, and vision (NRC 2000). Methymercury can be created from elemental mercury under low levels of oxygen (anoxia) in the presence of organic carbon and sulfate-reducing bacteria (NRC 2000, Wiener et al. 2003). These conditions exist in the sediments of tidal marshes and other estuarine environments.

The scour of Alviso Slough can increase habitat for aquatic resources, decrease the need for dredging (Goals Project 1999), and help sustain the adjoining tidal marsh. But the circulation of mercury-bearing sediments in Alviso Slough due to its scour might increase the risk of mercury accumulation in associated food webs. A study of the distribution of mercury within the predicted scour zone of Alviso Slough is therefore warranted.

Study Design Concepts

- □ Study Population: The sediments of the tidal reach of Alviso Slough that are likely to be scoured due to the restoration of adjoining tidal marshland, based on scour predictions provided by the Project Consultant Team.
- □ Study Site: Alviso Slough between the Alviso Yacht Club and San Francisco Bay.
- □ Parameters Measured: depth below sediment surface, total mercury, methylmercury, reactive mercury, total carbon, sulfur, Ph, conductivity, magnetic susceptibility, soil density, grain size.
- □ Study Design: The measured parameters will be profiled over depth in each of 15 5-cm diameter sediment cores 2-m long taken with a piston-corer; one core is taken at each of three stations for each of five cross-channel transects evenly spaced along the Study Site; the stations at each transect represent the left bank, mid-channel, and right bank of the scour zone. All cores will be photographed and x-rayed. Half of each core will be archived for further study if needed.
- □ Time Frame for Study: One-time study conducted in fall-winter 2005-06.
- □ Estimated Study Costs: $60,000-$70,000

Management Options

This study will determine whether or not the scour of Alvisio Slough due to the restoration of adjoining tidal marshland is likely to increase the bioavailability of mercury. If large loads of mercury are discovered within the zone of predicted scour, then the managers of the slough and adjacent lands will have alternative responses, including:

(a) conduct additional studies to further elucidate the extent of the potential problem (this might involve taking more cores to better describe the distribution and quantities of legacy mercury, and/or linking the core studies to sediment transport studies to assess the fate of any mobilized mercury);

(b) Adjust the amount of tidal marsh restoration to prevent the amount of scour that might mobilize the legacy mercury (the mercury may be concentrated at great enough depths that some marsh restoration and concomitant scour is allowable);

(c) remove the mercury-bearing sediment that is likely to scour and place it away from the biosphere (it may be possible to use the sediment with a safety cap to help fill deeply subsided salt ponds slated for tidal marsh restoration);

(d) proceed with tidal marsh restoration and monitor for increased bioaccumulation in sentinel species (provides no preventive measures, however);

(e) not restore tidal marsh along Alviso Slough (precludes major land use objective).

Citations

Beutel, M., and K. Abu-Saba. South Bay Salt Ponds Restoration Project: Mercury Technical Memorandum. Brown and Caldwell / Larry Walker and Associates. Report prepared for the South Bay Salt Ponds Restoration Project Management Team.

Coates, R., M. Swanson and P. Williams. 1989. Hydrologic analysis for coastal wetland restoration. Environ. Manage. 13(6):715-727.

Collins, L.M., J.N. Collins, and L.B. Leopold. 1987. Geomorphic processes of an estuarine tidal marsh: preliminary results and hypotheses. In: International Geomorphology 1986 Part I. V. Gardner (ed.). John Wiley and Sons, LTD.

Collins, J.N. and R. Grossinger. 2005. Syntheses of scientific knowledge for maintaining and improving functioning of the South Bay ecosystem and restoring tidal salt marsh and associated habitats over the next 50 years at pond and pond-complex scales. Report to the South Bay Salt Pond Restoration Project.

Dedrick, K.G. 1979. Effects of levees on tidal currents in marshland creeks. Abstracts of the G.K. Gilbert Symposium: San Francisco Bay its past, present, and future. Annual meeting of the Geological Society of America, 1979, San Jose, CA.

Dedrick. K.G. and L.T. Chu. 1993. Historical atlas of tidal creeks San Francisco Bay, California. Proceedings of the eighth symposium on coastal and ocean management (Coastal Zone 93). American Society of Engineers, New York, NY.

Dyer, K.R., 1995. Sediment transport processes in estuaries, in G.M.E. Perillo (ed). Geomorphology and Sedimentology of Estuaries. Developments in Sedimentology 53, Elsevier.

Goals Project. 1999. Baylands ecosystem habitat goals, A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, CA.

Leopold, L. B., J. N. Collins, and L. M. Collins. 1993. Hydrology of some tidal channels in estuarine marshlands near San Francisco, Catena, 20, 469–493.

NRC (National Research Council). 2000. Toxicological Effects of Methylmercury. National Academies Press, Washington DC.

Wiener, J.G., D.P. Krabbenhoft, G.H. Heinz, and A.M. Scheuhammer. 2003. Ecotoxicology of mercury. *In* Handbook of Ecotoxicology, 2nd edition. D.J. Hoffman, B.A. Rattner, G.A. Burton, and J. Cairns, eds. Boca Raton, CRC Press, pp. 409-463.

Williams, P.B. and M.K. Orr. 2002. Physical evolution of restored breached levee salt marshes in the San Francisco Bay Estuary. Restoration Ecology 10(3):527-542.

Applied Question # 12: Will tidal marsh restoration increase MeHg levels in indicative wildlife of managed ponds and tidal marsh?
Josh Collins, SFEI Wetland Scientist and Science Team Member

Background and Rationale

Mercury (Hg) is dangerously toxic to wildlife and people. The organic form of mercury (methylmercury or MeHg) is a neurotoxin that readily accumulates in food chains. Minamata disease, or methylmercury poisoning, is characterized by peripheral sensory loss, tremors, and loss of memory, hearing, and vision (NRC 2000). Methymercury can be created from elemental mercury under low levels of oxygen (anoxia) in the presence of organic carbon and sulfate-reducing bacteria (NRC 2000, Wiener et al.2003). These conditions exist in the sediments of tidal marshes and other estuarine environments (Marvin-DiPasquale et al. 2000, Marvin-DiPasquale and Agee. 2003).

The potential exists to inadvertently increase the risk of mercury (Hg) accumulating in South Bay fish and wildlife through hydrological modification of salt ponds as part of the South Bay Salt Pond Restoration Project (Project). Concentrations of Hg in sediment and water tend to be greater in South Bay due to past local mercury mining (Beutel and Abu-Saba 2004). The Alviso Pond and Slough Complex are especially worrisome because they contain more Hg than most other areas of South Bay (Conway et al. 2004, SFEI 2005) and because they are slated for early hydrologic modification by the Project.

Bayland managers need to know how their actions affect the risk of mercury bioavailability and toxicity. The risk can be assessed most directly by monitoring Hg in 'biosentinel' wildlife species that represent habitat conditions that typically result from the planned management actions. Coupling such a monitoring effort to studies of MeHg production and biological uptake is essential to understand how management actions can be adjusted to reduce the risk of Hg toxicity.

Study Design Concepts

- Study Population: Selected "biosentinel" species of invertebrates, fish, and birds that indicate local bioaccumulation of mercury. The candidate species must have a small home range, be easily collected, and be residential within a habitat type or feature that is targeted for restoration or enhancement by the Project.
- Study Site: The geographic scope of the study changes over three phases. Phase 1 is restricted to the major habitat types of Pond A8 and Alviso Slough plus ambient sites of these same habitat types. Phase 2 expands to encompass a survey of these habitat types in the South Bay. Phase 3 focuses on South bay locales of special interest identified during Phase 2.
- Parameters Measured: Phase 1 involves sampling mercury in selected sentinel species and characterizing the mercury in their habitats. The parameters for wetland habitats include total mercury, methylmercury, reactive mercury, total carbon, sulfur, Ph, conductivity, soil density, and grain size. The parameters for aquatic habitats include unfiltered total mercury, methylmercury, TSS, dissolved carbon, temperature, Ph, sulfur, and conductivity. Maps will be made of all habitat types surveyed.
- Study Design: The regional strategy for solving the mercury problem calls for an integrated program of monitoring plus focused research driven by questions and hypotheses that explicitly reflect the information needs of resource managers (Wiener et al. 2002). The proposed work would start by helping the Project Management Team define the mercury problem in practical terms, The work would then proceed to develop cost-effective indicators of the problem, survey its magnitude and extent (beginning with Pond A8 and its adjacent tidal habitats), test for correlations between the problem and manageable environmental factors, initiate research to understand the primary environmental factors most strongly influencing the observed correlations, and help translate these findings into recommended actions to either prevent or correct the problem.

  The work would be conducted in three phases over three years. The approach is scalable, however, and could be used to monitor any management action at any spatial scale from one local habitat patch to the South Baylands as a whole.

The conditions of existing pond and tidal habitat types will be surveyed as analogues for what could be maintained or restored in the pond complexes based on different management scenarios. For example, the tidal habitats to be surveyed in Phase 1 represent the habitats predicted for PondA8 restoration. The existing pond habitats to be surveyed represent the expected future conditions of Pond A8 if it is not restored to tidal marsh. The comparisons are based on sentinel species that are common to tidal and non-tidal habitats. For example, the same sentinel fish species will be sampled in Alviso Slough and Pond A8.

Phase 1 would:

- Develop sentinel species indicators of Hg exposure for Alviso Slough water column, pond water column, slough bottom, pond bottom, tidal marsh panne/pond margin, tidal marsh channels, tidal marsh vegetated plain;
- Assess the mercury problem for the habitat types listed above based on Hg concentrations in the associated sentinel species;
- Characterize the habitats in terms of their propensity to produce MeHg.

Phase 2 would:

- Expand the sentinel species survey to encompass more of the South Baylands. This phase provides a picture of the spatial variability in mercury problem within and between bayland habitats in South Bay.

Phase 3 would:

- Initiate focused research to better understand the linkages between Hg contamination in sentinel species and bio-goechemical indicators for specific habitat types in selected areas, based upon the results of Phase 2;
- Help translate the scientific understanding of the Hg problem into habitat designs and management options that minimize the problem.

□ Time Frame for Study: fall 2005 through winter 2008.

□ Estimated Study Costs: $750,000

Management Questions

Phase 1 of this study will initially determine the relative risks of mercury toxicity represented by different habitat types resulting from different management options for Pond A8. For example, if the ratio between the ambient slough benthic risk and the Alviso Slough benthic risk (based on the benthic sentinel species) is less than the ratio between the ambient slough benthic risk and the Pond A8 benthic risk, then the managers could assume that sampling breaching the pond would not result in a net increase in benthic risk. The same analyses will proceed for the other habitat types. If the restoration of Pond A8 is indicated to increase the net risk of mercury toxicity, then the managers might consider other options than simply breaching the pond, including:

(a) not breaching the pond;

(b) capping the sediments in the pond or removing them before restoring the pond to tidal action (this pertains to the condition that existing benthic conditions in the pond represent relatively high risk due to legacy mercury loads in the pond);

(c) breaching the pond but excluding any tidal habitats, such as marsh panes, small channels, or densely vegetated marsh plains, if their ambient conditions tend to represent relatively high risk;

(d) dredge Alviso Slough (this pertains to the condition that a relatively high risk of mercury toxicity in Alviso Slough is due to its legacy mercury load, and that the scour of these sediments and their possible transport into Pond A8 after it is breached represents a net increase in risk for restored tidal habitats in Pond A8).

Phase 2 of this study will profile the relative risk of mercury toxicity among the habitat types resulting from different planned management actions throughout the South Bay. This profile will provide the managers with a number of options, including:

(a) Assessing the importance of the risk of mercury toxicity relative to other stressors, such as gull predation, flood hazards, biological invasions, and accelerated sea level rise;

(b) Prioritizing the restoration or maintenance of habitat types and habitat features based on their relative contributions to the local and regional risk of mercury toxicity;

(c) Targeting research to explain the conditions of highest risk, and/or to establish threshold of mercury concentration among the sentinel species that correspond to significant biological harm

This option would be translated into Phase 3 of the study, which is designed to address the primary information needs of the managers based on the Phase 2 profile of South Bay conditions.

Citations

Beutel, M., and K. Abu-Saba. South Bay Salt Ponds Restoration Project: Mercury Technical Memorandum. Brown and Caldwell / Larry Walker and Associates. Report prepared for the South Bay Salt Ponds Restoration Project Management Team. 47 pp.

Conaway, C.H., Watson, E.B., Flanders, J.R., and Flegal, A.R., 2004, Mercury deposition in a tidal marsh of south San Francisco Bay downstream of the historic New Almaden mining district, California: Marine Chemistry, v. 90, p. 175–184.

Marvin-DiPasquale, M., and J.L. Agee. 2003. Microbial mercury cycling in sediments of the San Francisco Bay-Delta. Estuaries 26:1517-1528.

Marvin-DiPasquale, M., J. Agee, C. McGowan, R.S. Oremland, M. Thomas, D. Krabbenhoft, and C. Gilmour. 2000. Methyl-mercury degradation pathways: a comparison among three mercury-impacted ecosystems. Environmental Science and Technology 34:4908-4916.

NRC (National Research Council). 2000. Toxicological Effects of Methylmercury. National Academies Press, Washington DC.

SFEI. 2005. The Pulse of the Estuary 2005. San Francisco Estuary Institute, Oakland, California.

Wiener, J.G., D.P. Krabbenhoft, G.H. Heinz, and A.M. Scheuhammer. 2003. Ecotoxicology of mercury. *In* Handbook of Ecotoxicology, 2nd edition. D.J. Hoffman, B.A. Rattner, G.A. Burton, and J. Cairns, eds. Boca Raton, CRC Press, pp. 409-463.

Applied Studies Question 15: Will California gulls, ravens, crows, and native raptors adversely affect (through predation and/or encroaching on nesting areas) nesting birds in managed ponds?

Cheryl Strong, San Francisco Bay Bird Observatory
Josh Ackerman, U. S. Geological Survey Davis Field Station
Steve Rottenborn, H.T. Harvey and Associates

Background/Rationale

Project Objective 1 states that the South Bay Salt Pond Restoration Project will maintain current migratory bird species that utilize existing salt ponds and levees as well as support increased abundance and diversity of native species. Without adequate control and prevention measures, nuisance species such as the California Gull could hamper these objectives through displacement or predation of desired species. California Gulls are opportunistic feeders; their numbers have exponentially increased in the Bay area since first nesting in the early 1980's; over 30,000 now nest in the South Bay (Strong *et al*. 2004, and SFBBO unpub. data). Other species such as Common Ravens and American Crows have also increased in the Bay area in the last few decades largely due to their ability to exploit human-dominated landscapes in general and their ability to successfully nest in power towers and other structures above or adjacent to salt ponds (Josselyn *et al*. 2005, SFBBO unpub. data). Native raptors such as the Northern Harrier are expected to increase with tidal marsh restoration (MacWhirter and Bildstein 1996) and are known predators of the endangered Western Snowy Plover (Page *et al.* 1995). All of these species can be difficult to control in the environment and are likely to impact nesting birds within the restoration project to some extent. Although some level of predation and displacement occurs in all ecosystems, the consolidation of nesting gulls, shorebirds and terns into fewer ponds may increase levels within the restoration landscape to unacceptable levels.

To collect reliable information on this question, we recommend testing the following null hypotheses. Because of differences between the species, there are three hypotheses listed, one for each species or group below.

Ho_1: California Gull colony changes during tidal marsh restoration will not displace or reduce nesting shorebirds and terns.

> Ho_{1A}: Displacement of the California Gull colony at the Knapp pond will not reduce the number and/or location of other nesting bird species in the South Bay.
>
> Ho_{1B}: The movement and diet of California Gulls during the nesting season does not change, and therefore has no effect on the number and/or location of other nesting bird species in the South Bay.

Ho_2: Increased tidal marsh restoration will not increase predation of shorebirds and terns by corvids or other tower nesting species.

Ho_3: Increased tidal marsh restoration will not increase predation of shorebirds and terns by Northern Harriers or other marsh nesting raptors.

Ho_1: California Gull colony changes during tidal marsh restoration will not displace or reduce nesting shorebirds and terns.

> **Ho_{1A}: Displacement of the California Gull colony at the Knapp pond will not reduce the number and/or location of other nesting bird species in the South Bay.**

Relocation Dynamics of the Knapp Pond California Gull Colony

Background:
The largest California Gull colony in the Bay, ~20,000 birds, is located on a dried salt pond known as the Knapp pond (Pond A6), located near Alviso. Restoration of tidal action to the Knapp pond is currently proposed in Phase I, and is likely to cause the displacement of all or part of this colony. Nesting space may be available on salt pond levees elsewhere within the South Bay (where some gull colonies already exist), but nesting space in the long term will be limited by future tidal restoration, and at least some of the Knapp California Gulls may relocate to islands or levees currently used for nesting by other species. Relocation of 20,000 California Gulls to nesting sites elsewhere in the South Bay areas could potentially have a serious effect on terns and shorebirds as a result of their exclusion from nesting locations and an increase in predation. Given the imminent breaching of the Knapp pond, it is important to identify: (1) where the Knapp pond gulls will relocate; (2) approximate numbers expected to relocate to various parts of the estuary; and (3) the proximity of these sites to those of important nesting areas of Forster's Terns, Caspian Terns, American Avocets, Black-necked Stilts, and Western Snowy Plovers.

Applied Study Design:
1. The first step would be to color band a large sample of the Knapp gulls (>500 birds) in one part of the colony in one year. Color banding will require boom netting before egg-laying has begun so that we will not cause relocation of many banded birds in the initial year of banding.

2. In the year following banding, all gulls with territories in the boom netted section of the Knapp colony will be excluded from their site using wire or repellant over that area of the colony, preventing landing and nesting. Wire/repellant will be installed before the gulls have begun to reoccupy nest sites.

3. During normal colony reoccupation (March-April), a team of biologists will survey for color banded Knapp gulls that have relocated to other suitable nesting habitat in the Bay.

4. Using data on the locations of nesting terns, recurvirostrids, and plovers collected by SFBBO, PRBO, and USGS, the proximity of the relocated Knapp gulls to important breeding areas of other species (and thus, the potential threat to these species) will be determined.

5. We expect an immediate response from gulls within the second year of the study if enough are displaced from the Knapp colony. The banding/displacement may be expanded in subsequent years to bolster predictions of the effects of gull displacement on other South Bay nesting birds.
Management Responses:
If the displacement of the Knapp colony does not reduce the number and/or location of other nesting bird species in the South Bay, then the PMT should consider movement up the Adaptive Management staircase. Monitoring should continue to determine that gulls do not begin to affect other nesting species.

If the displacement of the Knapp colony does reduce other nesting bird species in the South Bay, then the Project Management Team may need to think about reducing the number of gulls or consider not moving up the Adaptive Management staircase. Various methods have been used to reduce the size of gull colonies, including allowing vegetation to cover over nesting and roosting sites, limiting roosting near landfills, using monofilament to cover the nesting site, scaring tactics, oiling eggs, and lethal control. All of the tactics may need to be used over a period of time (even years) to reduce the number of gulls and/or limit their nesting success. Limiting the amount of garbage at dumpsters, in parking lots, and at landfills may also help. Some of these methods would require permits from the USFWS that may be difficult to obtain.

Estimated Budget: $100,000

Ho$_1$: California Gull colony changes during tidal marsh restoration will not displace or reduce nesting shorebirds and terns.

> **Ho$_{1B}$: The movement and diet of California Gulls during the nesting season does not change, and therefore has no effect on the number and/or location of other nesting bird species in the South Bay.**

<u>California Gull foraging and breeding dynamics in the South Bay</u>

Background:
We will examine the breeding and foraging movements, distributions, and abundance of California Gulls throughout the South Bay salt ponds and associated landfills and determine the relative contribution of landfills to gull diet. These results will facilitate management decisions regarding colony placement, active gull management, and restoration of specific salt ponds for the South Bay Salt Pond Restoration Project.

Applied Study Design:
The study area will be the salt ponds in the San Francisco Bay National Wildlife Refuge complex and surrounding landfills. Radio-tracking will occur primarily in pond A6 (Knapp). Gull surveys will occur throughout the salt pond complex, including primary nesting sites in ponds A6, A9, 3A, M2, B2, and A1 and landfill foraging sites at Newby Island, Palo Alto, and Tri-Cities.

Objective 1. Monitor the current nesting and foraging distributions and abundance of California Gulls throughout the South Bay salt ponds and associated landfills.

We will conduct monthly gull surveys from March 1 to September 1 at each gull colony and landfill following existing protocols (Takekawa *et al.* 2001a,b; Strong *et al*. 2004). We will identify gulls to species, enumerate, and record gull activity as breeding, roosting, or foraging. Nesting gull surveys will be conducted once yearly during peak nesting (Strong *et al.* 2004). Gull distribution and densities will then be mapped using ArcView GIS (ESRI 1996). <u>This study is in progress through SFBBO and USGS.</u>

Objective2. Examine the movements of California Gulls from nesting to foraging sites using telemetry to determine their relative use of landfills and other habitats as foraging sites.

We will use radio or satellite telemetry to track the movements of California Gulls from nesting sites to foraging areas. In early spring, we will capture gulls using rocket nets (Dill and Thornsberry 1950) or nest traps set at colony sites. We will mark 30 California Gulls with U.S. Fish and Wildlife Service leg bands and a transmitter either attached to the leg or to a backpack harness (Belant *et al.* 1993, Takekawa *et al.* 2002, Ackerman 2004). We will then track gulls daily (if radio-tagged) using trucks equipped with dual 4-element Yagi antenna systems (Gilmer *et al.* 1982) or download locations on a regular basis (if using satellite transmitters).

Objective 3. Examine California Gull diet using stable isotope analysis of eggs and chicks, assess how the diet changes throughout the breeding season, and determine the relative contribution of landfills to sustaining gull populations as well as gull predation on locally breeding waterbirds.

We will use stable nitrogen, carbon, and sulfur isotope analyses to assess the relative contribution of anthropogenic food items (i.e. landfills) to gull diets (Hebert *et al.* 1999). Up to 45 eggs and 200 feather samples from chicks will be collected from California Gull colonies. Up to 50 reference samples will be collected to represent available diet items. We will establish baseline isotopic signatures of prey from the most likely foraging habitats, including food items common to landfills (chicken, beef, pork), and the bay and saltponds (fish [e.g., topsmelt and gobies], invertebrates [e.g., brine shrimp, snails], and nesting bird eggs and chicks [e.g., American Avocets]). We will also assess how diet changes over the course of a breeding season (Belant *et al*. 1993, Duhem *et al.* 2005) by examining differences in nitrogen, carbon, and sulfur values between eggs and chicks. We expect that shorebird eggs and chicks may become a more important component of gull diets later in the season (Ackerman, USGS, unpublished data), thus the isotope values would reflect a greater degree of marine nutrient input. <u>This study is partially funded for 2007 through USGS.</u>

Management Responses:
If the movement and diet of California Gulls during the nesting season does not change, and has no effect on the number and/or location of other nesting bird species in the South Bay the PMT can consider movement up the Adaptive Management staircase. Monitoring should continue to determine that gulls do not begin to negatively impact other nesting species.

If the movement and diet of California Gulls does change during the nesting season in a way that negatively affects other nesting species, then the PMT may need to think about reducing the number of gulls in the South Bay. (See above.)

Estimated budget: $85,000-150,000

Ho$_2$: Increased tidal marsh restoration will not increase predation of shorebirds and terns by corvids or other tower nesting species.

Ho$_3$: Increased tidal marsh restoration will not increase predation of shorebirds and terns by Northern Harriers or other marsh-nesting raptors.

American Crows, Common Ravens, and Native Raptor Management

If numbers of gulls, corvids, and native raptors negatively impact other nesting birds to a significant degree then a bay-wide avian predator control program will need to be implemented and likely maintained in perpetuity. Mammal control is contracted with Wildlife Services in the South Bay overall, but avian control currently exists only in the CDFG property of Eden Landing Ecological Reserve.
Various landscape-level factors may also reduce the impact of these species on nesting plovers and other birds if enacted on a broad scale.

Landscape level control:
1. limiting open food and water access, including landfills and dumpsters
2. power tower modification within pond and marsh areas
3. business park/housing development modifications to limit trees near the edge of ponds and marsh
4. removing perches within the pond and marsh areas
5. restoration design to limit Northern Harrier nesting habitat (tidal marsh channels) adjacent to plover or other shorebird nesting habitat (Note that this might conflict with recommendations to have vegetated areas near shorebird and tern nesting sites to give chicks a place to hide from gulls.)

If in the likely event that avian predator management becomes necessary on a large scale, there are various management techniques that can be used in addition to or in place of lethal control. For corvids, these include behavior modification (repellents, sterilants, conditioned taste aversion), and habitat modification (tower modification or removal, perch site removal, modification of anthropogenic food and water sources). While short-term solutions such as lethal removal and behavior modification may be necessary in some circumstances to avoid local population declines of threatened or endangered species, more effective methods for controlling corvid populations in the long run, and that may also benefit entire ecosystem function, are habitat restoration and modification of anthropogenic food and water sources. Because a number of landfills in the South Bay are in close proximity to restoration locations, management actions that deter corvids from eating garbage including installation of overhead wiring, use of chemical repellents, scare tactics, and covering waste with at least 15 cm of soil or a synthetic cover, could help reduce corvid population levels (Josselyn *et al.* 2005).

Because Northern Harriers are included in the "support increased abundance and diversity of native species" restoration design should be attempted before lethal control is implemented.

Literature Cited

Ackerman, J. T., J. Adams, J. Y. Takekawa, H. R. Carter, D. L. Whitworth, S. H. Newman, R. T. Golightly, and D. L. Orthmeyer. 2004. Effects of radio transmitters on the reproductive performance of Cassin's auklets. Wildlife Society Bulletin 32: 1229-1241.

elant, J. L., T. W. Seamens, S. W. Gabrey, and S. K. Ickes. 1993. Importance of landfills to nesting herring gulls. Condor 95:817-830.

Dill, H. H., and W. H. Thornsberry. 1950. A cannon projected net trap for capturing waterfowl. Journal of Wildlife Management 14:132-137.

Duhem, C., E. Vidal, P. Roche, and J. Legrand. 2005. How is the diet of yellow-legged gull chicks influenced by parents' accessibility to landfills? Waterbirds 28:46-52.

ESRI. 1996. ArcView GIS: Using ArcView GIS. Environmental Systems Research Institute, Inc., Redlands, CA, USA.

Gilmer, D. S., M. R. Miller, R. D. Bauer, and J. R. LeDonne. 1982. California's Central Valley wintering waterfowl: concerns and challenges. Transactions of the North American Wildlife and Natural Resources Conference 47:441-452.

Hebert, C. E., J. L. Shutt, K. A. Hobson, and D. V. C. Weseloh. 1999. Spatial and temporal differences in the diet of Great Lakes herring gulls (*Larus argentatus*): evidence from stable isotope analysis. Canadian Journal of Fish and Aquatic Science 56:323-338.

Josselyn, M. A. Hatch, C. Strong, and F. Nichols. 2005. Science Synthesis for Issue 8: Impact of Invasive Species and other Nuisance Species. Report to the South Bay Salt Pond Restoration Project, State Coastal Conservancy, Oakland, CA. URL: www.southbayrestoration.org/Science.html

MacWhirter, R. B., and K. L. Bildstein. 1996. Northern Harrier (Circus cyaneus). In The Birds of North America, No. 210 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Page, G. W., J. S. Warriner, J. C. Warriner, and P. W. C. Paton. 1995. Snowy Plover (*Charadrius alexandrinus*). *In* The Birds of North America, No. 154 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Strong, C. M., L. B. Spear, T. P. Ryan, and R. E. Dakin. 2004. Forster's Tern, Caspian Tern, and California Gull colonies in the San Francisco Bay: habitat use, numbers and trends, 1982-2003. Waterbirds 27:411-423.

Takekawa, J. Y., A. K. Miles, D. H. Schoellhamer, G. Martinelli, M. K. Saiki, and W. G. Duffy. 2001a. Science support for wetland restoration in the Napa-Sonoma salt ponds, San Francisco Bay estuary, 2000 progress report. Unpubl. Prog. Rep. USGS, Davis and Vallejo, CA. 66pp.

Takekawa, J. Y., C. T. Lu, and R. T. Pratt. 2001b. Avian communities in baylands and artificial salt evaporation ponds of the San Francisco Bay estuary. Hydrobiologia 466: 317-328.

Takekawa, J. Y., N. Warnock, G. Martinelli, A. K. Miles, and D. Tsao. 2002. Waterbird use of bayland wetlands in the San Francisco Bay estuary: movements of long-billed dowitchers during the winter. Waterbirds 25: 93-105.

Applied Studies 16, 17, and 18: Descriptions for the Public Access Key Uncertainty
Lynne Trulio, South Bay Salt Pond Restoration Project, Lead Scientist/Science Team Member

Introduction
The Science Team identified three Applied Studies questions to address Public Access, a Key Uncertainty in achieving the Project Objectives for the South Bay Salt Pond Restoration Project. One primary Project Objective (PO# 3) is to provide adequate, high quality access for visitors to the restoration area. To achieve this, we must understand the local public's recreational interests and, currently, there is little information of local origin. To anticipate public access demand, it is important to track the public's interests and needs, as these will change over time.

The Project also has the primary objective to restore and manage habitats for the benefit of species and ecosystem functioning (PO #1). Research indicates that human disturbance, including public access, can have negative effects on species and habitats (see Trulio, 2005 for a review of this literature). Thus, the public access and ecological Project Objectives may, to some extent, be in conflict. The potential impacts of public access on many important South Bay species and habitats are unknown and must be studied to reduce the uncertainties involved with achieving both Project Objectives.

The following descriptions for the three Public Access Applied Studies questions give a background for each question as well as general study design concepts and potential management responses to the information generated by the studies.

Applied Studies Question #16: Will increases in boating access significantly affect birds, harbor seals or other target species on short or long timescales?
Lynne Trulio, South Bay Salt Pond Restoration Project, Lead Scientist/Science Team Member

Background
Project Objective #3 states that the South Bay Salt Pond Restoration Project will provide public access opportunities compatible with wildlife and habitat goals. The Project plans boating oriented features such as kayak and small boat launches, which are expected to increase recreational boating traffic. In addition, the Water Trail, a designated water route for recreational boaters, is being developed and sites within the Project will be destination points along this route. Personal watercraft, such as jet skis and wave runners, with their shallow drafts, can access "wilderness areas" previously inaccessible to motorboats (National Park Service 1998). Boating generated by the Project has the potential to negatively affect waterbirds and harbor seals.

There is a very large body of literature on the effects of human disturbance on species. Researchers agree that breeding birds are very sensitive to human disturbance, whether the disturbance is from trail use, boats, or research (Carney and Sydeman 1999, Burger and Gochfeld 1993, Keller 1991, Burger 1981). Studies of watercraft effect found that disturbances from boats can result in nest abandonment and reproduction failure of breeding adult waterbirds (Burger 1998; Erwin, et al. 1995). In general, nesting birds exhibit abnormal behavioral, growth, or reproductive effects (Mikola et al. 1994; Rodgers and Smith 1997), while foraging birds move away from areas of high boating activity with varying degrees of habituation (Burger 1998; Kaiser and Fritzell 1984). Due to high-density nesting habits, colonial breeding birds are particularly susceptible to boating disturbances. Rodgers and Smith (1995, 1997) studied the impacts of outboard boating, canoeing, and walking on several species of colonial waterbirds in Florida. The distance at which the birds flushed depended on the species, disturbance source, habituation, and colony type.

As with breeding birds, researchers found watercraft type affects non-breeding birds in different ways. Rodgers and Schwikert (2002, 2003) showed that waterbirds flushed at significantly longer distances when approached by faster and noisier propeller-driven airboats compared to slower, quieter outboard motorboats. In addition, larger birds flushed sooner than smaller species, no matter what the boat type, probably due to their slower take-off times. In general, the faster and louder the approach, the sooner birds will flush and the larger the waterbird the sooner it will flush. A study at Aquatic Park in Berkeley, CA found ducks, flushed in response to a kayak in the 30-70 m range, depending on species and size of group (Avocet Research Associates 2005). Rodgers and Schwikert (2003) also found that there was high variation in flushing distances within species; habituation may be one reason for this variation.

In San Francisco Bay, recreational boating is a major source of behavioral changes, particularly haul-out patterns, in the Pacific harbor seal (Farallones Marine Sanctuary Association 2000). The effects of disturbance range from mild to severe, from a hauled-out seal raising its head at the sound of a disturbance to being struck and killed by boats. Harbor seals are vulnerable to "harassment by persons on shore and boaters and kayakers from [San Francisco] Bay" and "will flush from haul-out sites at 300 meters" (Lidicker and Ainley 2000). Kayakers can cause greater disturbance to resting seals than powerboat operators because of their tendency to travel close to the shoreline. Kayakers also create disturbances at a greater distance from the seals than do powerboat operators (Suryan and Harvey 1999). Subsequent disturbances, however, have a greater rate of recovery. Suryan and Harvey (1999) suggest two possible explanations: 1) seals become more tolerant of boating disturbances; or 2) seals that are most affected by the initial harassment have already moved on to another haul-out site. Females will remain in the water until the danger passes before returning to their pups. This is important where haul-out sites, and particularly pupping sites, are few in number (Suryan and Harvey 1999). Because harassment increases seals' energy expenditure by decreasing haul-out period, harassment has the greatest impact on nursing pups and molting adults, when haul-out is most critical (Suryan and Harvey 1999).

The literature indicates the need for two studies of boating effects on wildlife:

1. What is the effect of boating generated by the Project on waterbirds, especially non-nesting birds?
2. What is the effect of boating generated by the Project on harbor seals during pupping and non-pupping seasons? (This research should be coordinated with research on harbor seals connected with Applied Studies Question #10.)

Study Design Concepts

At this point in the Project, we recommend specific hypotheses or research questions be designed to address these two questions.

These two studies are very different from each other and will require different research methods.

1. <u>What is the effect of boating generated by the Project on waterbirds, especially non-nesting birds?</u>

Study Design Concepts

- ❑ <u>Study Population</u>: Study boaters both within and near the Project area. Study waterbirds, especially migratory species—both shorebirds and waterfowl--found in the Project area.
- ❑ <u>Study Sites</u>: Compare areas frequented by boaters to control sites, where boaters are absent or rare. Study both open bay and slough sites.
- ❑ <u>Parameters Measured</u>: Flight initiation distance in response to boaters; species richness and abundance in boater and non-boater areas; effects on nesting birds, such as nest success rates (if boaters are approaching nesting areas).
- ❑ <u>Study Design</u>: Choose at least 3 boater-use and 3 control sites within or near the Project area, south of the San Mateo Bridge, in each habitat type (open Bay, slough). Collect data 2 or more times per month for two full years. Some control data should be taken at area planned for facilities before the facilities are put in, to do a Before-After-Control-Impact (BACI) study. Analyze data by species, bird group size, season, etc. in response to boater group size and activity.
- ❑ <u>Time Frame for Study</u>: Baseline data collection should begin before boating facilities are constructed and before the Water Trail is officially designated. Some or all of this data may have been collected by USGS. Then, begin the two-year boater site-Control study approximately a year after boating features are installed.
- ❑ <u>Estimated Study Cost</u>: Study will require a team effort by experienced researchers. Tentative cost estimate: $100,000 for entire study.

2. <u>What is the effect of boating generated by the Project on harbor seals during pupping and non-pupping seasons?</u>

- ❑ <u>Study Population</u>: Study harbor seal population south of the San Mateo Bridge, which is typically divided into groups that haul at known locations, including Bair Island, Alviso Slough and Mowry Slough. Study boaters and seals using these areas.
- ❑ <u>Study Sites</u>: Harbor seal haul-out and pupping sites in the South Bay.
- ❑ <u>Parameters Measured</u>: Immediate behavioral responses to boaters; number of seals in boat-use versus Control areas; movement of seals around the South Bay in response to boaters; tidal cycle and seasonal responses to boaters.
- ❑ <u>Study Design</u>: Some parameters, such as immediate behavioral responses, can be achieved with an observational study of unmarked animals. Capturing, marking and using radio-telemetry will be needed for other studies, such as movements around the South Bay.

- Time Frame for Study: Study can begin now to provide basic locational and behavioral information; study for 2-3 years. Repeat this work after boating facilities are completed. Conduct marking/radio-telemetry after boating facilities completed; study for 1-2 years.
- Estimated Study Cost: Observational study of immediate behavioral responses has been initiated by Kathy Fox, Master of Science student, Department of Environmental Study, San Jose State University. Tentative cost estimate: $20,000. Radio-telemetry study tentative estimated cost: $100,000.

Management Options

The effect of public access on wildlife is one of the most contentious aspects of the Project. Providing high-quality public access and recreation is critical to the goals of the Project and also for general public support. But, managers must be sure access is designed and provided in such a way that species are protected. Research is needed to give managers relevant information to achieve both goals.

Both studies will give managers information on the extent of boating effects on sensitive species. Information on flush/response distances will allow managers to estimate the amount of habitat that is compromised by boating activities. Managers may seek to limit the area of impact and/or ensure that enough undisturbed habitat is provided. Information on seasonal sensitivities will allow managers to protect wildlife at sensitive times of the year, through education and seasonal area closures.

The waterbird study will give managers valuable information on different responses of species and guilds in roosting and foraging habitat, which can be used to protect specific areas and in educational materials. Harbor seal telemetry will fill a major data gap—How do seals move about and use the Bay and do they move in response to human disturbance? This critical information will give managers insight into the overall habitat needs of the harbor seal population, once again for protecting habitat, directing boating to minimize impact and educating the public.

Findings will be used to design public access so that it does not have significant impacts on the target species. Design may include keeping public at an appropriate distance from wildlife, permitting only certain recreational activities, excluding public access with significant impacts altogether, or allowing public access with significant impacts in certain proscribed areas while maintaining large refuges with no public access.

Citations

Burger, J. 1981. The effect of human activity on birds at a coastal bay. Biological Conservation 21:231-241.

Burger, J. and M. Gochfeld. 1993. Tourism and short-term behavioral responses of nesting masked, red-footed and blue-footed boobies in the Galapagos. Environmental Conservation 20:255-259.

Carney, K.M. and W.J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68-79.

Farallones Marine Sanctuary Association. 2000. SEALS Program Annual Report: 1999. San Francisco: National Oceanic and Atmospheric Administration.

Kaiser, M.S. and E.K. Fritzell. 1984. Effects of river recreationists on green-backed heron behavior. Journal of Wildlife Management 48:561-567.

Keller, V.E. 1991. Effects of human disturbance on eider ducklings Somateria mollissima in an estuarine habitat in Scotland. Biological Conservation 58: 213-228.

Mikola, J., M. Miettinen, E. Lehikoinen and K. Lehtila. 1994. The effects of disturbance caused by boating on survival and behavior of velvet scoter *Melanitta fusca* ducklings. Biological Conservation 67: 119-124.

Rodgers, J.A., Jr. and H.T. Smith. 1997. Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida. Wildlife Society Bulletin 25:139-145.

Rodgers, J. A., and H. T. Smith. 1995. Set-back distances to protect nesting bird colonies from human disturbance in Florida. Conservation Biology 9:89-99.

Rodgers, J.A., Jr. and S.T. Schwikert. 2002. Buffer zone distances to protect foraging and loafing waterbirds from disturbance by personal watercraft and outboard-powered boats. Conservation Biology 16:216-224.

Rodgers, J.A., Jr. and S.T. Schwikert. 2003. Buffer zone distances to protect foraging and loafing waterbirds from disturbance by airboats in Florida. Waterbirds 26:437-443.

Suryan, R.M., and J.T. Harvey. 1999. Variability in reactions of Pacific harbor seals, *Phoca vitulina richardsi*, to disturbance. Fishery Bulletin 97:332-9.

Applied Studies Question #17: Will landside public access significantly affect birds or other target species on short or long timescales?
Lynne Trulio, South Bay Salt Pond Restoration Project, Lead Scientist/Science Team Member

Background
Project Objective #3 states that the South Bay Salt Pond Restoration Project will provide public access opportunities compatible with wildlife and habitat goals. The FWS and DFG are dedicated to providing high-quality recreational opportunities as part of the Restoration Project. However, the potential for conflict exists between the goals of restoring and managing habitat for wildlife (Objective 1) and providing public access (Objective 3) (Delong 2002). Researchers agree that breeding birds are very sensitive to human disturbance, whether the disturbance is from trail use, boats, or research (Carney and Sydeman 1999). In their review of human disturbance of nesting colonial waterbirds, Carney and Sydeman (1999) found scientific research and visitors (recreationists and ecotourists) had a range of impacts on a number of nesting species. Studies of landside recreational activities and non-breeding shorebirds, waterfowl and colonial waterbirds show that bird responses vary based on a number of factors, such as proximity of approach, directness of approach, species, time of year, habituation, location, speed of movement, and type of recreational activity. Direct approaches by people on foot are very disruptive causing flight and reduced foraging times in a many shorebird species compared with undisturbed birds (Thomas, et al. 2003, Burger and Gochfeld 1993). Burger and Gochfeld (1991) also found that pedestrians always disturbed shorebirds if they approached birds directly, but there was no significant disturbance from walkers a path. Some species are more sensitive than others. Pease et al. (2005) and Klein, et al. (1995) found that ducks exhibited significant negative responses to birding, walking and bicycling. Other studies (Josselyn et al., 1989; Rodgers and Schwikert, 2003) have found that larger birds flush at much greater distances in response to human presence than smaller birds. Gill et al. (2001) studied the abundance of black-tailed godwits (*Limosa limosa*) at four coastal estuaries in England and found no effect of human activities, including footpath use, on bird numbers. Habituation is also an important factor. For example, Ikuta and Blumstein (2003) found birds were significantly more sensitive to disturbance at the low human use sites, suggesting birds became habituated to humans in the high traffic areas. In their study of trail use effects around the San Francisco Bay, Trulio and Sokale (in review) found, overall, no consistent difference in bird numbers, species richness or foraging behavior of between trail and non-trail sites dominated by shorebirds at three locations around the San Francisco Bay. Tangential trails with no fast or loud vehicles and the dominance of small shorebirds may have contributed to these results.

The literature indicates a need for these specific studies:

1. What is the effect of trail use on waterfowl? Many trails are planned adjacent to ponded habitat, but we have no information on how waterfowl might respond to those trails.

2. What is the effect of trail use on California clapper rails? We also have no data on the effects of trail use on California clapper rail habitat use and breeding. Wildlife agencies assume the effect is negative, but there are no data to support that assumption.

3. At what distance should nesting islands must be placed from trails for various species to avoid impacts? Nesting birds are very sensitive to human disturbance, but the distance at which that impact is negligible is unknown.

4. What is the response of shorebirds at sites before trails exist compared to after they are opened? Studies of shorebird response to trails before and after trails are introduced would add to our knowledge of trail effects on shorebirds.

Study Design Concepts
1. What is the effect of trail use on waterfowl?
   - ❑ <u>Study Population and Sites</u>: Waterfowl in the South Bay, especially those in ponds designated for public access, as well as at non-public access sites.
   - ❑ <u>Parameters Measured</u>: Bird buffer distances, sustained changes in abundance and/or species richness, impacts to bird survival, availability and quality of impacted and non-impacted habitat
   - ❑ <u>Study Design</u>: For buffer distances, study the distances birds are distributed from levees not used for public access and those that are. Calculate the amount of area that is impacted, i.e. from which birds are excluded, when disturbed by people.
   - ❑ <u>Time Frame for Study</u>: 1-2 years

- ❑ Estimated Study Cost: Tentative cost estimate: $20,000. This study is underway by Heather White, Master of Science Student, Environmental Studies Department, San Jose State University.

2. What is the effect of trail use on California clapper rails? This study would need to be designed in conjunction with US Fish and Wildlife Service Refuge and Endangered Species staff.

3. At what distance should nesting islands must be placed from trails for various species to avoid impacts? See Pond A16/SF2 experiment for this design.

4. What is the response of shorebirds at sites before trails exist compared to after they are opened? See Pond E12/13 experiment for this design.

Management Options

Findings will be used to design public access so that it does not have significant impacts on the target species. Design may include keeping public at an appropriate distance from wildlife, permitting only certain recreational activities, excluding public access with significant impacts altogether, or allowing public access with significant impacts in certain proscribed areas while maintaining large refuges with no public access.

Citations

Burger, J. and M. Gochfeld. 1991. Human activity influence and diurnal and nocturnal foraging of sanderlings (*Calidris alba*). Condor 93:259-265.

Burger, J. and M. Gochfeld. 1993. Tourism and short-term behavioral responses of nesting masked, red-footed and blue-footed boobies in the Galapagos. Environmental Conservation 20:255-259.

Carney, K.M., Sydeman, W.J., 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22, 68-79.

DeLong, A.K., 2002. Managing visitor use and disturbance in waterbirds—a literature review of impacts and mitigation measures. Prepared for Stillwater National Wildlife Refuge. Appendix L (114 pp.) *in* Stillwater National Wildlife Refuge Complex Final Environmental Impact Statement for the Comprehensive Conservation Plan and Boundary Revision (Vol. II). Dept. of the Interior, U.S. Fish and Wildlife Service, Region 1, Portland, OR.

Gill, J.A., Norris, K., Sutherland, W.J., 2001. The effects of disturbance on habitat use by black-tailed godwits, *Limosa limosa*. Journal of Applied Ecology 38, 846-856.

Ikuta, L.A., Blumstein, D. T., 2003. Do fences protect birds from human disturbance? Biological Conservation 112, 447-452.

Josselyn, M., Martindale, M., Duffield, J., 1989. Public access and wetlands: impacts of recreational use. Technical Report #9. Romberg Tiburon Center, Tiburon, California.

Klein, M.L., Humphrey, S.R., Percival, H.F., 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. Conservation Biology 9, 1454-1465.

Pease, M.L., Rose, R.K., Butler, M.M., 2005. Effects of human disturbances on the behavior of wintering ducks. Wildlife Society Bulletin 33, 103-112.

Rodgers, J.A., Jr., Schwikert, S.T., 2003. Buffer zone distances to protect foraging and loafing waterbirds from disturbance by airboats in Florida. Waterbirds 26, 437-443.

Thomas, K., Kvitek, R.G., Bretz, C., 2003. Effects of human activity on the foraging behavior of sanderlings, *Calidris alba*. Biological Conservation 109, 67-71.

Applied Studies Question #18: Will public access features provide the recreation and access experiences visitors and the public want over short or long timescales?
Lynne Trulio, South Bay Salt Pond Restoration Project, Lead Scientist/Science Team Member

Background/Rationale

Project Objective #3 states that the South Bay Salt Pond Restoration Project will provide public access opportunities compatible with wildlife and habitat goals. A primary step in achieving this objective is to clearly understand the public's needs and wants for visitor access to the restoration area. The Project's land managers, US Fish and Wildlife Service and the California Department of Fish and Game, allow a range of recreational activity on their lands including hunting, fishing, wildlife viewing, research, photography, environmental education, and interpretation. The Restoration Project is planning to provide a range of public access opportunities in its Phase 1 Project, such as hunting, non-motorized trails, kayak launches, interpretive stations at the Eden Landing salt works and other sites, and overlooks.

Many recent studies of recreational pursuits show increased interest in some activities and declines in others. The 2001 report of National Survey of Fishing, Hunting, and Wildlife-Associated Recreation shows that by 2001 the popularity of these activities had increased from 1996 levels (US Department of the Interior 2003). In California, public survey polls conducted in 1987 showed that outdoor recreation was important to 44% of Californians. This percentage increased to 62% in 1997 (California Department of Parks and Recreation 2002).

In California, participation in all trail activities increased significantly in the last 15 years; bicycling doubled and hiking increased by 50% from 1987 to 1992 (California Department of Parks and Recreation 2002). California's population is expected to grow from its current level of 34 million to 45 million by 2020, further fueling the demand for recreational opportunities. California Department of Parks and Recreation (2002) reports that popular recreational activities of significance to the Restoration Project include recreational walking, driving for pleasure, trail hiking, general nature and wildlife study, bicycling on paved surfaces, visiting historic sites, attending outdoor cultural events, and picnicking at developed sites. Recreational trends show increasing interest in nature study and wildlife viewing, especially among two growing demographic groups, Hispanics and seniors, and a general continued interest in motorized recreation, such as "all terrain vehicles" (ATVs) and personal watercraft. Two traditional recreational uses, hunting and fishing, continue to decline in popularity.

While many questions about public access demand could be studied, two information gaps relative to the Project stand out:

6. What are the public access interests of San Francisco Bay Area residents and visitors?
7. Do the features that the Project provides meet the public's needs in the short and long-term?

At this point in the Project, we recommend specific hypotheses or research questions be designed to address these two questions.

Study Design Concepts

Both these questions could be addressed with well-designed public surveys. The two studies should use compatible data collection methods so that the data compliment each other. Some specific ideas on study designs for each question are as follows.

1. <u>What are the public access interests of San Francisco Bay Area residents and visitors?</u>

- ❑ <u>Study Population</u>: Regional scale needed. Sample the population south of the San Mateo Bridge, but could expand to the greater Bay area. Randomly sample overall population and recreationists; sample residents and tourists/visitors
- ❑ <u>Study Sites</u>: Recreational and non-recreational facilities
- ❑ <u>Parameters Measured</u>: Demographic parameters (age, ethnicity, residence, etc.); Types of recreation/public access engaged in, where and how often; Types of recreation/public access desired; Knowledge of restoration and the Project, in particular; Willingness to support restoration and associated public access
- ❑ <u>Study Design</u>: Survey administered to study population; stratified random sample design
- ❑ <u>Time Frame for Study</u>: Can be administered any time; a year or less of data collection should be adequate. Should be repeated every 5-10 years
- ❑ <u>Estimated Study Cost</u>: Could be undertaken by a qualified graduate student with direct involvement of major professor. Tentative cost estimate: $30,000-50,000

2. <u>Do the features the that Project provides meet the public's needs in the short and long-term?</u>

- ❑ <u>Study Population</u>: Sample visitors to the Project's different public access features.
- ❑ <u>Study Sites</u>: Recreational and non-recreational facilities within the Project area
- ❑ <u>Parameters Measured</u>: Demographic parameters (age, ethnicity, residence, etc.); Project public access features used most often and why; Opinions of the public access provided by the Project; Types of recreation/public access desired; Types of recreation/public access engaged in, where and how often; Willingness to support restoration and associated public access

- ❑ <u>Study Design</u>: Survey administered to study population; include weekdays and weekends
- ❑ <u>Time Frame for Study</u>: Administer during Phase 1, after public access features have been available for at least a year; collect data over all four seasons and during weekdays, weekends and holidays. Should be repeated with each new Project phase and after major changes, of any sort, to existing phases.

- Estimated Study Cost: Could be undertaken by a qualified graduate student with direct involvement of major professor. Tentative cost estimate: $30,000-50,000

Management Options

The results of the first study will provide specific and local information to the land managers on recreational trends and desires of Bay Area residents. This information should be used to adjust existing public access opportunities in the Project area and for designing valued public access features into future Project phases that *anticipates* demand.

The second study will give managers information on how visitors to the Project's public access amenities might use and view those features. Specifically, if some features are not well-used or of interest to the public, they might be converted to features that are attractive. Features that are popular should be increased, if wildlife impacts and funding make this possible. Of course, this information will be very valuable in designing the public access features of future phases.

The information collected by these studies must be acted upon in a *public manner*. If the public is happy with the access that the Project is providing, the Project should celebrate this achievement in public outreach tools, such as newsletters, the website, press releases, and the like. If the public seeks changes, the Project should make those public access changes if possible, based on wildlife needs, funding, etc.; if the changes are not possible, the PMT should make efforts, though meetings and public outreach tools, to explain why requested changes cannot be made. Public responses to people's needs and interests will promote support of the Project and for future phases. Not to address public access demands is to risk negative public sentiment that could prevent movement of the Project up the Adaptive Management staircase.

Citations

California Department of Parks and Recreation. 2002. California Outdoor Recreation Plan. 78 pp. The Resources Agency, Sacramento, CA. Retrieved from the internet on September 4, 2004. http://www.parks.ca.gov/default.asp?page_id=796

Trulio, L.A. 2005. Science Synthesis for Issue 9: Understanding the Effects of Public Access and Recreation on Wildlife and their Habitats in the Restoration Project Area. Report to the South Bay Salt Pond Restoration Project, State Coastal Conservancy, Oakland, CA. URL: **www.southbayrestoration.org/Science.html**

U.S. Department of the Interior, Fish and Wildlife Service and U.S Department of Commerce, U.S. Census Bureau. 2003. 2001 National Survey of Fishing, Hunting and Wildlife-associated Recreation: California (revised). 86 pp. Retrieved from the internet on September 4, 2004. http://www.census.gov/prod/www/abs/fishing.html .

Applied Studies 19, 20, and 21: Descriptions for the Social Dynamics Key Uncertainty
Lois M. Takahashi, South Bay Salt Pond Restoration Project, Science Team Member

Introduction
The overall goal of the South Bay Salt Pond Restoration Project's planning process is to develop a scientifically-sound, publicly-supported plan. Clearly, an effective planning process requires an understanding of the public's needs and attitudes toward restoration, particularly of this project's proposed improvements. But in addition what is also necessary is an understanding of the ways in which population change, urban development, and political shifts interact with ecological restoration to affect management decisions. Current public attitudes and the potential influence of longer term social, political, and economic shifts on the restoration project comprise key uncertainties that challenge the potential effectiveness of adaptive management and proposed restoration.[1]

Though the uncertainties stemming from social dynamics are most clearly related to the Project Objective focused on human interactions (PO#3), all the Project Objectives have political, economic, or social aspects that may make adaptive management difficult and challenging. Indeed, some have argued that without an understanding and incorporation of social elements, ecosystem management projects may be "even worse than doing nothing."[2] In terms of public access (PO#3), rapid growth and change in population near the project sites may affect public satisfaction with the project because of added demand for access, or in contrast because of changes in public interest associated with the restoration project, public support may wane or increase.

The Project Objectives associated with public service delivery (PO #2, 5, 6) have clear political and economic elements, related to jurisdictional governance issues (such as responsibility and accountability) and the distribution of costs and benefits associated with restoration efforts. Even the more ecological Project Objectives (PO #1, 4) are significantly affected by social dynamics, particularly in terms of the pressures brought by population growth in the region (e.g., groundwater demand, stormwater run-off, solid waste creation and services, and degraded air quality associated with increased traffic congestion), global economic forces (e.g., cargo ship traffic) and climate change (e.g., increasing urbanization and deforestation world-wide).

Though many researchers are assessing the possible influence of varying social dynamics on habitats and environments, the particular character of social, political, and economic change in the South Bay, and its relationship to environmental quality and management remain largely unclear. These uncertainties should be studied and clarified to ensure that adaptive management will be able to respond to what are likely to be significant shifts in population and politics over the 50-year project timeline.

Three Social Dynamics questions have been identified as needing in-depth scientific investigation for the project to meet its objectives. The following descriptions provide a background for each question, general study design concepts and potential management responses that address the study results.

Applied Studies Question 19: Will voters, advocacy groups, elected officials, and government agencies support the project (especially in terms of funding) over the short timescale at the local and regional spatial scales?
Lois M. Takahashi, South Bay Salt Pond Restoration Project, Science Team Member

Background/Rationale
Stated public support for the restoration project is a necessary, though not sufficient, requirement for successful passage of ballot initiatives associated with new public funding sources such as tax assessments and bonds. Stated support is not sufficient since behavior (such as voting for an initiative or bond measure) and stated attitudes are not necessarily directly linked. Attitudes and behavior have been shown in many cases to have weak correlations, but research building on the

---

[1] Young, T.P. (2000), "Restoration ecology and conservation biology," in Biological Conservation 92: 73-83 makes the argument that habitat degradation is significantly defined by global population growth rates, land use and abandonment, and public awareness of the importance of biodiversity.
[2] Carpenter, S., W. Brock, and P. Hanson (1999). "Ecological and social dynamics in simple models of ecosystem management," Conservation Ecology 3(2): 4. [online] URL: http://www.consecol.org/vol3/iss2/art4/ (last accessed 6 February 2006).

Theory of Reasoned Action[3] has suggested that those with stronger opinions and attitudes (compared to neutral or weak attitudes) tend to behave in line with their stated attitudes.[4]

Some researchers have argued that an environmentalist ideology is the most important predictor of support for environmental regulations or laws.[5] Others have argued in contrast that environmentalist ideologies are less important than income and occupation in explaining voting for ballot initiatives associated with environmental regulations. In one study, [6] individuals who were lower income and employed in the construction, extractive industries (farming, forestry), and manufacturing were usually opposed to environmental ballot initiatives. This suggests that voting behavior for environmental ballot initiatives might be driven by a "'self-interest' theory of environmental demand"[7] rather than primarily by a collectivist view on environmental protection. In other words, though restoration projects tend to be communicated to various stakeholders and interest groups through an environmentalist ideological framework, what might be as important if these results hold for initiatives proposing funding for restoration projects, are the income and occupational characteristics of potential voters and other important stakeholders.

Part of the challenge in gaining and sustaining public support is the very long time span of the restoration project. One issue related to this challenge is the relative lack of evidence clearly indicating the effectiveness of an adaptive management approach. There are few examples of adaptive management projects that have been in place long enough or been systematic enough to provide evidence. One adaptive management project in northwest Australia on ground fisheries, to show "practical results in fisheries management" required a decade of implementation – US examples (e.g., U.S. Forest Service's consensus management plan for coastal forests in California, Oregon, and Washington; Plum Creek Timber Company's habitat conservation plan; US Department of Interior's Glen Canyon Dam habitat project in the Grand Canyon) have tended to not be as systematic as the Australian case.[8]

Communicating the importance and benefits of the project to various interests requires that there is trust both in the information used to describe the project and in the institutions relaying the information.[9] Barriers to building and sustaining trust include intergovernmental conflict (such as specific agencies' desire to control data, and efforts to maximize "biological or economic yield" through single species management) and the "domination" of policy surrounding the project by single/few stakeholders, clients, or funders.[10] Trust and credibility might be enhanced by shifting "from traditional, expert-driven" processes to more community-based assessment and monitoring efforts.[11]

To determine what strategies might be most effective in promoting public support of the project, what is needed is a clearer understanding of the degree of support for the project, the characteristics (e.g., demographic, ideological, etc.) associated with support, and possible competing issues or needs dominating public discourse and voting behavior.

<u>Study Design Concepts</u>

The study measures the degree of support (both stated and behavioral) by relevant individuals, communities, and groups critical to successful planning (e.g., vocal support during public

---

[3] Ajzen, Icek and Martin Fishbein (1980). <u>Understanding Attitudes and Predicting Social Behavior</u>, Englewood Cliffs, N: Prentice Hall.

[4] See review in Takahashi, Lois M. (1998). <u>Homelessness, AIDS, and Stigmatization: The NIMBY Syndrome at the end of the Twentieth Century</u>. Oxford, England: Oxford University Press.

[5] Samdahl, Diane M. and Robert Robertson (1989). "Social Determinants of Environmental Concern: Specification and Test of the Model," <u>Environment and Behavior</u> 21(1): 57-81.

[6] Kahn, Matthew E. and John G. Matsusaka (1997). "Demand for Environmental Goods: Evidence from Voting Patterns on California Initiatives," <u>Journal of Law and Economics</u> 40(1): 137-173.

[7] Ibid, p. 140.

[8] Lee, K. N. (1999). "Appraising adaptive management," <u>Conservation Ecology</u> 3(2): 3. [online] URL: http://www.consecol.org/vol3/iss2/art3/ (last accessed 6 February 2006).

[9] Kunreuther, Howard, Fitzgerald, Kevin, and Aarts, Thomas D. (1993). "Siting Noxious Facilities: A Test of the Facility Siting Credo," <u>Risk Analysis</u> 13(3): 301-318.

[10] Pinkerton, E. (1999). "Factors in overcoming barriers to implementing co-management in British Columbia salmon fisheries," <u>Conservation Ecology</u> 3(2): 2. [online] URL: http://www.consecol.org/vol3/iss2/art2/ (last accessed 6 February 2006), pp. 6-8.

[11] Corburn, Jason (2002). "Environmental Justice, Local Knowledge, and Risk: The Discourse of a Community-Based Cumulative Exposure Assessment," <u>Environmental Management</u> 29(4): 451–466; quote on p. 464.

hearings), funding (e.g., voters for assessment or bond measures), and implementation (e.g., sustained support through initial and later phases of the project). The most important issue is the degree of public support (where public is broadly defined, including residents, businesses, advocacy groups, but with a focus on likely voters) for funding for implementation.

- Study Population: Scale depends on funding mechanism, likely cities and counties, with special focus on jurisdictions adjacent to project sites. Two populations are appropriate given resources for study. For very limited resources, focus on South Bay state legislators/aides and local elected officials. If larger pool of available resources, population would consist of South Bay residents, especially likely voters.
- Study Sites: For elected officials, conduct short telephone interview; for likely voters, conduct focus groups (if limited resources) or telephone/web-based survey.
- Parameters Measured: For elected officials, assess perception of public support for restoration project. For focus groups and/or survey, measure demographic parameters (age, ethnicity, gender, residence, occupation, income categories, etc.); environmental ideology; knowledge about restoration and location/ecological condition of specific project sites; perception about benefits and costs of project.
- Study Design: For elected officials, semi-structured interview with interview guide. For focus groups, selection of 8-12 unrelated individuals for discussion, semi-structured discussion facilitated by trained researcher, taped for further analysis. For telephone survey, questionnaire administered via telephone or Internet (though this will bias the sample toward better educated, wealthier voters), stratified random sample design.
- Time Frame for Study: Should be conducted at several points prior to funding mechanism's critical juncture (e.g., election day for ballot measure, public comment period for plan, etc.). Several points in time will provide opportunities for developing public education, social marketing, or advocacy campaign for public support of project. Data collection should be limited to relatively short time frame (2-3 weeks for focus groups or survey) to reduce external influences on measures (i.e., a longer time frame runs the risk of having important social, political, or economic events occur during data collection, which would reduce the comparability of data for the sample portion contacted prior to and after the significant event).
- Estimated Study Cost: For elected officials, requires individual familiar with elected officials and their aides who could access these individuals in a timely manner. Ballpark cost estimate: $50,000. For focus groups, requires facilitator/analyst, transcriber (of audiotapes), cash incentives for participants ($50-$100 each), incidentals (food, transportation, childcare, etc.); assuming between 3-5 focus groups conducted twice prior to the critical funding mechanism, ballpark cost estimate: $50,000. For the telephone/web-based survey, which is the most expensive option, a very rough estimate would be $150,000-$200,000.

Management Response

While the project generally does not seem to be a hot-button issue in terms of opposition and there seems to be general support for habitat restoration in the Bay Area, there are factors that may impede public and political support, such as competing funding initiatives and very local community concerns. Researchers have also cautioned that even if opposition or conflict are not encountered in planning phase, care should be taken to ensure that controversies and concerns are investigated as conflict can flare during implementation and management phases.

The results of this study would provide managers with current information on the level of support, the characteristics of supporters and non-supporters, and the potential reasons for lack of support. With this information, project managers will be better able to craft public education, social marketing, or advocacy campaigns to increase public support (both stated and behavioral) of the project.

Applied Studies Question 20: What are the benefits and costs associated with the project sites and will they be shared equitably among communities, businesses, municipalities, and/or government agencies at local and regional scales?
Lois M. Takahashi, South Bay Salt Pond Restoration Project, Science Team Member

Background/Rationale

For management decisions to be made and for public support to be attained, in addition to the ecological and biotic dimensions of restoration, science will likely need to also focus on the political, social, and particularly the economic value of the project. Clarifying the economic dimensions places this project in the context of and in comparison to other public concerns (i.e., the trade-offs involved in focusing public and private resources on this project versus other noteworthy issues).

Researchers tend to view the environment as a collective or public good, and efforts to restore sites are seen as collective or communal activities.[12] But if the potential benefits and costs are to be measured and communicated to the public and specific interest groups, one necessary step is to take a more pragmatic approach by clarifying the value of the restoration project. Determining the value of the restoration project, however, is a complex endeavor. Cost-benefit analysis provides a quantitative means of assessing the appropriateness or feasibility of options by comparing the costs (including opportunity costs) with benefits accruing to specific actions. Benefits accrue to individuals/communities/businesses (private benefits) or to the public at large (public benefits); the same is true for costs.

> It [cost-benefit analysis] attempts to express all beneficial consequences of an action ($B) and all costs or detrimental consequences ($C) in monetary terms, usually discounted to net present values. Alternative actions are then ranked according to the ratios ($B/$C) or the differences ($B - $C) of benefits and costs. Cost-benefit analysis has the advantages of appealing to a widely-held goal, financial efficiency, and of incorporating different parties' assessments of costs and benefits. It has the disadvantages of not dealing with uncertainty, of obscuring rather than illuminating trade-offs among non-financial objectives, and of offering little help in structuring negotiations.[13]

As this quote indicates, this approach should be used with caution because cost-benefit analysis steers managers and decisionmakers "to adopt only those limited investments in environmental practices which can yield monetary [and by extension programmatic, political, or biotic] benefits within an economic time frame."[14]

Productive activities (e.g., building a bridge or transportation system) as well as publicly perceived negative actions (e.g., polluting) have been assessed using cost-benefit analysis. In one cost-benefit analysis of the private and public benefits and costs associated with conservation programs, for example, the largest benefits were "increases in the value of market sales of farm commodities and reductions in commodity deficiency payments from the Commodity Credit Corporation (CCC)" while the largest costs were "direct CRP [Conservation Reserve Program] costs and increased consumer food costs."[15] Another study analyzed the trade-offs between the costs and benefits of lake pollution (over-enrichment of lakes), and found that the potential benefits from polluting included the profits gained by farmers or developers, while costs included not being able to use the lake's water as a source for drinking water, farming or manufacturing, or for recreation.[16]

While cost-benefit analysis can help to identify the varied economic dimensions of ecologically-focused projects, it does not eliminate issues of inequity or different values concerning the environment, nor does it necessarily make conflicting values more transparent. As one researcher found in an analysis of watershed management in the Pacific Northwest:

> there are also obvious (although generally unacknowledged) asymmetries in the distribution of the costs and benefits of environmental protection between these various constituencies – between, for example, different types of users of resources at the local

---

[12] Light, Andrew and Eric Higgs (1996). "The Politics of Ecological Restoration," Environmental Ethics 18: 227-247.

[13] Maguire, Lynn A. and Lindsley G. Boiney (1994). "Resolving Environmental Disputes: A Framework Incorporating Decision Analysis and Dispute Resolution Techniques," Journal of Environmental Management 42: 31-48; quote on p. 32.

[14] Sharma, Sanjay and Harrie Vredenburg (1998). "Proactive Corporate Environmental Strategy and the Development of Competitively Valuable Organizational Capabilities," Strategic Management Journal 19: 729-753; quote on p. 730.

[15] Feather, Peter, Daniel Hellerstein, and LeRoy Hansen (1999). "Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs: The Case of the CRP," Report prepared for the Economic Research Service of the US Department of Agriculture. Washington, DC: US Department of Agriculture; quote on p. 6.

[16] Carpenter, S., W. Brock, and P. Hanson (1999). "Ecological and social dynamics in simple models of ecosystem management," Conservation Ecology 3(2): 4. [online] URL: http://www.consecol.org/vol3/iss2/art4/ (last accessed 6 February 2006).

level, and local and more distant 'publics'.[17]

Consequently, cost-benefit analysis must be conducted in a rigorous and transparent manner, but should not be used in lieu of a larger and inclusive process of discussion, negotiation, and management of varied interests.

Study Design Concepts

The study measures the local and regional costs and benefits, in monetary terms, associated with the project sites. The costs and benefits should include biotic and habitat dimensions, as well as impacts on local and regional economies, air and water quality, and potential effects on transportation and infrastructure.

- ❑ Study Population: Local and regional scales. Study would include local and regional economies, ecosystems, infrastructure and transportation systems, and other relevant factors.
- ❑ Study Sites: South Bay region, with an emphasis on municipalities and jurisdictions adjacent to the project sites.
- ❑ Parameters Measured: Costs and benefits should include biotic and habitat dimensions, as well as impacts on local and regional economies, air and water quality, and potential effects on transportation and infrastructure.
- ❑ Study Design: Secondary analysis of existing data (demographic, transportation, infrastructure, etc.) using appropriate projections (e.g., population, industrial sector change, etc.) and econometric modeling techniques. Potential primary data collection for important factors with limited existing information. May require integration of multiple distinct models.
- ❑ Time Frame for Study: Study relies primarily on secondary analysis, but may require primary data collection and analysis (and incorporation of model results into larger integrated model). Could probably be completed within 12 months. Should be completed prior to implementation of project, preferably initiated during planning process.
- ❑ Estimated Study Cost: Economic analyses are generally quite expensive. Because this study may also require primary data collection and integrated model development and analysis, a ballpark cost estimate has a wide range: $200,000 - $300,000 (if no data collection, only secondary analysis, projections, and integrated model development); $400,000+ if primary data collection needed.

Management Response

Cost-benefit analysis would provide an economic valuation of the project, and would help to clarify the benefits and costs locally and regionally so that varying stakeholders could better understand the short- and medium-term impacts of the project. The results of a cost-benefit analysis using an integrated model (e.g.,, with population projections, monetary valuation of biotic and habitat restoration, etc.) would clarify to cities, government agencies, advocacy organizations, and residents the trade-offs involved in the project in monetary terms (making comparisons to other proposals and projects more feasible). Though cost-benefit analysis has inherent within it biases (see above discussion), such analysis also provides a solid baseline from which discussions and negotiations can be initiated.

Applied Studies Question 21: Will negative impacts associated with population growth and development adjacent to the project sites and beyond be successfully managed over the long timescale at the regional scale?

Lois M. Takahashi, South Bay Salt Pond Restoration Project, Science Team Member

Background/Rationale

The project's 50-year time frame means that a myriad of complex and challenging issues will affect the ability of project managers to adapt to changing circumstances. Population size, the activities associated with human presence (such as agriculture, recreation, and economic activities such as local, regional, and international commerce), and the transformation of land use/cover associated with population growth and human activities are all elements that will affect

[17] Singleton, Sara (2002). "Collaborative Environmental Planning in the American West: The Good, the Bad, and the Ugly," Environmental Politics 11(3): 54-75; quote on p. 68.

the project in significant ways.[18] Human settlement and population growth constitute primary challenges to effective management of the project – "urbanization has been identified as a primary cause, singly or in association with other factors, for declines in more than half of the species listed as threatened or endangered under the U.S. Endangered Species Act."[19]

Planning and implementation of ecosystem restoration projects, however, tend not to engage with planning and action associated with urban and regional development, creating a large level of uncertainty for the project's longer-term outcomes.[20] In addition, researchers still know little about ecosystem restoration challenges in urban, suburban, and exurban locations – the focus of researchers has instead largely been on "lands with a relatively small human presence, often dominated by resource extraction and agriculture."[21]

There are two conceptual approaches to understanding the impacts of human presence on the environment. The first approach assumes that population growth has negative impacts on environmental conditions. Those who advocate such a neo-Malthusian approach believe, simply put, that more people use more resources. From this perspective, population growth is part of a larger system where "materials and energy" flow through "the chain of extraction, production, consumption, and disposal of modern industrial society."[22] Population growth globally is consequently seen as associated with increasing energy demand, which, in turn, increases air pollution from fossil fuel combustion, local and transboundary water and ocean pollution due to effluents, and climate change resulting from "greenhouse" gases.[23] The second approach begins with the argument that neither population nor poverty alone is the most important cause for environmental impacts from human presence. Instead, a "land use/land-cover change" approach focuses on "the alteration of the land surface and its biotic cover,"[24] combining social science through a focus on land use and with natural science through a focus on the physical landscape and biota. Sources of land cover change should be seen as the result of "peoples' responses to economic opportunities, as mediated by institutional factors,"[25] or in other words, "changing consumption and behavioral patterns."[26]

No matter the perspective used to think about the potential long-term environmental impacts associated with development in the South Bay, what is clear is that adaptive management of the restoration project will require information and analysis about the size, composition, and density of populations and development and their impacts on the project sites over the 50-year time frame. The South Bay is no exception to global trends toward land cover change and environmental degradation. For example, economic growth in the region associated

---

18 Vitousek, Peter M., Harold A. Mooney, Jane Lubchenco, Jerry M. Melillo (1997). "Human Domination of Earth's Ecosystems," Science 277(25 July): 494-499.

19 Miller, James R. and Richard J. Hobbs (2002). "Conservation Where People Live and Work," Conservation Biology 16(2): 330-337; quote on p. 332.

20 Slocombe, D. Scott (1993). "Environmental Planning, Ecosystem Science, and Ecosystem Approaches for Integrating Environment and Development," Environmental Management 17(3): 289-303.

21 Miller, James R. and Richard J. Hobbs (2002). "Conservation Where People Live and Work," Conservation Biology 16(2): 330-337; quote on p. 330.

22 Meyer, William B. and B. L. Turner II (1992). "Human Population Growth and Global Land-Use/Cover Change," Annual Review of Ecology and Systematics 23: 39-61; quote on p. 39.

23 Holdren, John P. (1991). "Population and the Energy Problem," Population and Environment 12(3): 231-255.

24 Meyer, William B. and B. L. Turner II (1992). "Human Population Growth and Global Land-Use/Cover Change," Annual Review of Ecology and Systematics 23: 39-61; quote on p. 39.

25 Lambin, Eric F., B.L. Turner, Helmut J. Geist, Samuel B. Agbola, Arild Angelsen, John W. Bruce, Oliver T. Coomes, Rodolfo Dirzo, Gunther Fischer, Carl Folke, P.S. George, Katherine Homewood, Jacques Imbernon, Rik Leemans, Xiubin Li, Emilio F. Moran, Michael Mortimore, P.S. Ramakrishnan, John F. Richards, Helle Skanes, Will Steffen, Glenn D. Stone, Uno Svedin, Tom A. Veldkamp, Coleen Vogel, Jianchu Xu (2001). "The causes of land-use and land-cover change: moving beyond the myths," Global Environmental Change 11: 261–269; quote on p. 261.

26 Lambin, Eric F., B.L. Turner, Helmut J. Geist, Samuel B. Agbola, Arild Angelsen, John W. Bruce, Oliver T. Coomes, Rodolfo Dirzo, Gunther Fischer, Carl Folke, P.S. George, Katherine Homewood, Jacques Imbernon, Rik Leemans, Xiubin Li, Emilio F. Moran, Michael Mortimore, P.S. Ramakrishnan, John F. Richards, Helle Skanes, Will Steffen, Glenn D. Stone, Uno Svedin, Tom A. Veldkamp, Coleen Vogel, Jianchu Xu (2001). "The causes of land-use and land-cover change: moving beyond the myths," Global Environmental Change 11: 261–269; quote on p. 266.

with global trade will bring continued environmental change. For example, nonnative species associated with ballast water discharge from cargo ships[27] will likely increase given increased activities at Bay Area ports and economic development and trade with Pacific Rim nations, especially China. Land use patterns, such as urbanization (and in the South Bay, suburbanization and densification), and changes in land cover, such as intensification of agriculture or densification of housing development, contribute to local, regional, and global environmental degradation in various ways, including reducing biotic diversity, exacerbating climate change at the local, regional, and global levels, worsening soil degradation, and reducing the ability of ecosystems to provide services that benefit populations.[28]

Study Design Concepts

The study develops long-term (50-year time frame) projections of population, employment, and development in the South Bay, and potential effects on habitat and biota at the project sites. The projections and evaluation of environmental impacts should include biotic and habitat dimensions, stemming from population change (e.g., projections of population size, composition, and density), the activities associated with population change (e.g., projections of employment centers, housing, retail/commercial, and industrial development), and the negative environmental impacts of population change and human behavior (e.g., air and water pollution, land cover change). The study will develop an integrated model using projections of human settlement and public service/infrastructure system change, and provide scenarios or potential portraits of impacts on the project's habitat and biota (given projections, estimates, or targets of the restoration project).

- Study Population: South Bay region (human settlement, economic activity, and habitat/biota).
- Study Sites: South Bay region, with an emphasis on municipalities and jurisdictions adjacent to the project sites.
- Parameters Measured: Projections of population size, composition, and density; projections of change in employment, housing, and commercial markets; change in transportation, infrastructure, and other public systems important to the quality of the project's habitat and biota; impacts on biota and habitat associated with these changes.
- Study Design: Goal is to develop projections of impacts for 50-year project time frame. Secondary analysis of existing data (demographic, transportation, infrastructure, etc.) using appropriate projections (e.g., population, industrial sector change, etc.). Primary field data collection for habitat and biota (using data collected through monitoring proposed for adaptive management. Simulation models of impacts from population, market activity, industrial sector shifts on habitat and biotic quality/health.
- Time Frame for Study: Study relies primarily on secondary analysis, and large integrated model should be updated every 5-10 years. The first model could probably be completed within 24 months. Updates of the model will probably take less time, perhaps 10-12 months. Initial study results would be most useful prior to implementation, but would also provide useful information for ongoing evaluation of project.
- Estimated Study Cost: This is a complex study, requiring an interdisciplinary team (ecologists – especially specialists on biota and habitat impacts from human presence, and social scientists – especially demographers, economists, geographers). Ballpark cost estimate: $300,000+.

Management Response

Because ecosystem restoration projects (and other environmental policies and programs) are long-term in nature, there are a multitude of political, economic, and social uncertainties along with the ecological uncertainties that will continue to affect long-term outcomes. Though there have been some efforts to use socio-demographic projections as background for environmental

---

[27] Drake, John M. and Reuben P. Keller (2004). "Environmental Justice Alert: Do Developing Nations Bear the Burden of Risk for Invasive Species?," BioScience 54(8): 718-719.

[28] Lambin, Eric F., B.L. Turner, Helmut J. Geist, Samuel B. Agbola, Arild Angelsen, John W. Bruce, Oliver T. Coomes, Rodolfo Dirzo, Gunther Fischer, Carl Folke, P.S. George, Katherine Homewood, Jacques Imbernon, Rik Leemans, Xiubin Li, Emilio F. Moran, Michael Mortimore, P.S. Ramakrishnan, John F. Richards, Helle Skanes, Will Steffen, Glenn D. Stone, Uno Svedin, Tom A. Veldkamp, Coleen Vogel, Jianchu Xu (2001). "The causes of land-use and land-cover change: moving beyond the myths," Global Environmental Change 11: 261–269.

management,[29] conceptual and empirical models of the interactions between urban development and ecosystem restoration are rare. The results from this study are quite important to show stakeholders, decisionmakers, and the public at large the potential interactions between ongoing development and the Project Objectives. Though the results of this study would be largely based on projections and simulations, this study would still provide a tangible portrait of the project's potential impacts and an opportunity to clarify ecological interactions with social dynamics at the local and regional scales.

[29] For example, see Struglia, Rachel, Patricia L. Winter, and Andrea Meyer (2003). "Southern California socioeconomic assessment: Sociodemographic conditions, projections, and quality of life indices." Gen. Tech. Rep. PSW-GTR-187. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Integrative, Mechanistic Model (Proposal for Model Development)

Tidal Marsh Restoration in San Francisco Bay: Evaluating External Effects under Uncertainty

Investigators:
Mark Stacey, University of California-Berkeley
Thomas Powell, University of California-Berkeley
Oliver Fringer, Stanford University
Jeff Koseff, Stanford University

Historically, marshlands were ubiquitous around the San Francisco Bay estuary, with large portions of South San Francisco Bay, San Pablo Bay and Suisun Bay fringed by tidal marsh habitat. Over the past century, these marshes have been "reclaimed" for development, mostly having been put into production as salt ponds. Recently, restoration of these habitats to recover ecosystem function is being pursued at an accelerating pace. The largest single effort in this regard is the South Bay Salt Pond Restoration Project (SBSPRP), which involves the acquisition of more than 15,000 acres of salt ponds by the state of California and the federal government. In the North Bay, the CALFED process has established momentum for marsh restoration in the Sacramento-San Joaquin Delta, with restorations being discussed for tracts along Dutch Slough, Van Sickle Island and many others. Other examples of restoration projects throughout the estuary include Bair Island near Redwood City, and several projects around the perimeter of San Pablo Bay including the Napa Salt Ponds, Cullinan Ranch and Hamilton Field. In each case, the restoration of tidal wetlands will be coupled with the physical and ecosystem dynamics of the adjoining estuary, and the success of the restoration project, as well as the condition of existing estuarine ecosystems, will be shaped by that interaction.

While the goal of restoring native habitats and associated ecosystem function is certainly laudable and carries great benefits, restoration of tidal marsh habitat at the scale that is being pursued is not without its risks. These risks include effects both within the project domains and external effects of the projects on other, existing, habitats. Within the project domain, negative outcomes would include an incomplete recovery of marsh habitat (due to, say, insufficient sediment supply or a lack of vegetation recruitment) or poor quality habitat, which could be due to the detailed spatial structures of the restored habitat and its connection with adjoining habitats, the mobilization of contaminants at the site or other perturbations to the habitat that reduce its ecosystem function.

The uncertainty that surrounds the prospects for restoration success is compounded by uncertainties in the driving natural and anthropogenic processes, particularly at the decadal timescales of interest. Climate change (and variability) is likely to alter oceanic conditions, both through sea level rise and changes in the temperature and biota associated with oceanic waters. Further, the hydrology of the watersheds surrounding the estuary is likely to adjust in response to climate change, including the amount and timing of freshwater flows and the associated sediment supply. In an urban setting like San Francisco Bay, sediment supply will also be altered due to shifts in land use over the decadal timescale of interest. Finally, policies that govern how humans interact with the restored habitats will be dynamic, and create additional uncertainty for the success of the projects.

While much of the analysis to date has focused on the uncertainties associated with the success of the restoration projects, of equal, if not greater, importance are the risks to exterior habitats (beyond the project boundaries) that are created by the restoration process. Due to subsidence of much of the land considered for restoration, the restored areas are expected to accrete sediment for an extended period as they build themselves up to approach marsh elevations. As a result, during the restoration process, the overall sediment budget for the estuarine system will be altered by the presence of large "sinks" of sediments along the perimeter (at the restoration sites). To assess the impact of restoration on existing habitats, sediment transport pathways must be evaluated, including the prospects for scour or accretion in existing habitats. This consideration is also important in evaluating the quality of the restored habitats, due to the presence of sequestered contaminants at depth in many existing habitats (e.g., Mercury in San Pablo Bay). The movement of these sediment-associated contaminants into marshes may lead to increases in their transformation to bio-available forms, due to effects of vegetation on the level of oxidation of marsh sediments (Marvin-DiPasquale et al. 2000, 2003). In order to effectively analyze and predict sediment transport in the system, including the perturbation created by restoration, the adjustment of the system, including tidal forcing and salinity transport in addition to sediment suspension and deposition patterns, must be critically evaluated.

While changes to the patterns of suspended sediment concentration and transport are likely to be relatively quick to appear, other external impacts are more likely to develop over time. For example, the creation of extensive marsh habitat along the estuarine perimeter constitutes a major ecological change for the system. Already, the interaction of salt pond habitats with the estuary has led to the introduction of new species not traditionally associated with South San Francisco Bay (Cloern, 2006). The eventual adjustment of the estuarine ecosystem to the presence of fringing wetlands may not be complete for decades and is filled with tremendous uncertainty. Any predictive analysis of this trajectory, however, will require a basic understanding of transport and turbidity in the estuary, which are the emphasis of the work we are describing here.

In order to accurately analyze and predict the progression of habitat restoration in the face of both internal and external uncertainties, as well as the external impacts of the restoration activity, a modeling tool must be developed and applied that can accurately resolve tidal dynamics, transport and sediment suspension and deposition. These processes force us to consider a wide range of spatial scales. At the small scale, the interactions of tidal and wind-forced motions with the local bathymetry are likely to dominate the analysis of the net sediment movement into the restoration site (Ralston and Stacey 2006), as well as the scour and deposition of sediments in existing habitats in the vicinity. At the same time, though, the analysis must be able to address the estuary-scale dynamics, including exchange between the major subembayments in the estuary (South Bay, Central Bay, San Pablo Bay, Suisun Bay) and between the estuary and the coastal ocean. This combination of requirements necessitates the use of a numerical tool that can provide great detail (high resolution) at local scales of interest, but can also address questions and concerns at the scale of the estuary as a whole. Temporally, while the primary concerns and uncertainties involve the procession of restoration and the adjustment of the estuary at the timescale of years to decades, short timescale processes due to tidal and wind forcing dominate the net sediment and salinity transport that will determine the longer timescale trajectory of the system. Together, we require a flexible numerical tool that can accurately and efficiently simulate tidal and wind motions at the local scale of the restoration projects, but can also expand to the estuary as a whole.

On its own, however, a numerical tool does not constitute a modeling system. To be clear, observations of the system, including the local topography and the local influence of tides and winds on flows, mixing and transport of sediment and other scalars, are required to both calibrate the numerical tool and to confirm our physical understanding of the processes being simulated. To make this description of an integrated modeling system more specific we can consider the question of how Coyote Creek and the intertidal habitats along its perimeter are scoured (or otherwise modified) by the activities of the SBSPRP. In this case, any modeling efforts must be certain to accurately capture shear stresses and sediment transport at the scale of Coyote Creek and the adjoining Sloughs. At the same time, if we were interested in how the SBSPRP as a whole modifies the annual sediment budget for the San Francisco Bay Estuary, the detailed tidal dynamics of perimeter sloughs become less important. This example illustrates the need for careful calibration and verification of a modeling tool *at the spatial and temporal scales of interest.* The distinction here is between a *numerical* modeling exercise and an *approach* to modeling an environmental system. Numerically, a model can be expanded to include any domain or the grid can be reduced to resolve any feature; this does not make it an effective model for all processes being simulated.

The modeling system that we aim to develop relies on a flexible three-dimensional hydrodynamic and sediment transport model (SUNTANS, see Fringer et al. 2006) to predict how restoration actions will interact with the existing estuarine system, including changes in local tidal dynamics, salinity and suspended sediment concentrations. The flexibility in the numerical approach allows for highly resolved studies in and around particular restoration sites, while not compromising complete Bay coverage (through a variable grid spacing). While our initial modeling efforts will focus on the tidal and wind-forced dynamics, and their influence on transport of salinity and suspended sediments, this modeling approach provides a necessary foundation on which other, cross-disciplinary modeling efforts can be built. For example, modeling the mobilization of metals and their transformation into bioavailable forms would rely heavily on an understanding of how sediment moves through the system due to the strong association of these contaminants with sediments. Ecologically, primary productivity in the estuary is sensitive to the extent of penetration of light into the water column, so understanding and predicting how the turbidity (suspended sediment concentration) will adjust following restoration activity is a necessary first step. In each case, we aim to provide the physical "infrastructure" on which interdisciplinary models can be layered.

At the same time, it is critical that the numerical analysis be coupled with observations of physical processes (forcing and resulting flows and transport) and bathymetry at the scales of interest. The observational needs will vary between projects due to the existence of other observational efforts. In the far South Bay, for example, detailed studies of lower Coyote Creek (March-May 2006) and the flows through an Island Pond Breach (September-November 2006) are likely to provide an excellent foundation for calibrating and verifying a numerical model for the interaction of the region south of the Dumbarton Narrows with the SBSPRP. At a larger scale, the development of an ocean observing system, which is expected to extend into the Bay (CeNCOOS, see http://www.cencoos.org/), along with previous transect observations (Fram et al. 2006), provide an important foundation for considering ocean-estuary exchange. During the early stages of development, these observations will need to be somewhat extensive, as the details of slough-mudflat exchange and other small-scale, local, processes have not really been explored sufficiently to establish our physical understanding. With each successive application of the modeling system, however, fewer physical process-based observations will be required, perhaps only involving a detailed survey of the local bathymetry and a few basic calibration-oriented data sets.

While the mechanistic details of the development of this modeling system are beyond the scope of this short summary, we would like to note a few of the applications that the model will allow us to consider. First, the interannual variability in the sediment supply for the restoration projects can be considered by resolving the annual cycle of sediment deposition and redistribution, with consideration of the potentially important influence of extreme events. Secondly, long-term shifts in climatic forcing and land use can be addressed by considering how changes in oceanic conditions (rising sea level as well as shifts in oceanic conditions) and hydrologic forcing (riverflow timing and magnitude as well as sediment loading) affect the restoration projects and interact with those projects to define the long-term adjustment of the estuarine ecosystem.

Detailed Description of Activities and Associated Budget

Considering a three-year research time horizon, we now describe briefly a specific set of research activities that are motivated by the general discussion in this document. First, we will pursue an analysis of sediment transport in the region south of the Dumbarton Narrows (the Far South Bay) and the influence of annual variability in sediment supply. This activity would consist of both numerical development as described in this document and continued analysis of data sets collected in conjunction with the SBSPRP; the first examines the detailed dynamics of Coyote Creek adjacent to early breaches in the project (the Island Ponds) and the second data set examines flows and transport through a breach in detail. The data analysis would be focused on both developing an understanding of the basic physical processes that dominate sediment transport and establishing a reliable calibration and verification data set for the numerical activity at the scale of interest. Next, we will pursue modeling and analysis of a second site of similar scale to the Far South Bay modeling exercise. The specific choice of a site would be based on what data is available for calibration and verification purposes, most likely a San Pablo Bay restoration site. Finally, in both of these modeling exercises, we will evaluate the performance of the model in Central Bay using existing measurements of currents, salinity, temperature and suspended sediment (Fram et al. 2006). This final exercise is motivated by our interest in using our modeling approach to examine the effects of restoration at the scale of the entire estuary; the Central Bay data sets provide a rigorous test of the model's ability to extend to those spatial scales. To summarize these activities:

- Transport analysis and modeling South of the Dumbarton Narrows, including annual variability
- Transport modeling at a second restoration site to be determined (likely to be San Pablo Bay)
- Evaluation of model performance in Central Bay near the Golden Gate.

A rough budget for these activities, based on a three-year time horizon is $750,000 or about $125,000 per year for each institution (UC-Berkeley and Stanford). This estimate of the budget includes 1 graduate student researcher at each institution, salary support for each PI to contribute during summer months, and allowance for miscellaneous supplies and expenses related to computational facilities, publications and travel.

References

Cloern, J.E., 2006, "Surprising Trends of Phytoplankton Increase in South San Francisco Bay," presentation at the *South Bay Science Symposium*, June 6, 2006, San Jose, CA.

Fram, J.P., Martin, M.and Stacey, M. T. "Dispersive fluxes between the coastal ocean and a semi-enclosed estuarine basin," accepted for publication in *Journal of Physical Oceanography*, 2006

Fringer, O.B., Gerritsen, M. and Street, R.L. 2006. "An unstructured-grid, finite-volume, nonhydrostatic, parallel coastal-ocean simulator", *Ocean Modelling*, v.14 (3-4), pp. 139-173.

Marvin-DiPasquale, M.C., Agee, J.L., McGowan, C., Oremland, R.S., Thomas, M., Krabbenhoft, D. and Gilmour, C.C. 2000. "Methyl-mercury degradation pathways: A comparison among three mercury-impacted ecosystems," *Env. Sci. & Tech*., v.34(23), pp.4908-4916.

Marvin-DiPasquale, M.C., Agee, J.L., Bouse, R.M. and Jaffe, B.E. 2003. "Microbial cycling of mercury in contaminated pelagic and wetland sediments of San Pablo Bay, California," *Environmental Geology*, v.43(3), pp.260-267.

Ralston, D.K. and Stacey, M.T. 2006. "Tidal and meteorological forcing of sediment transport in tributary mudflat channels (San Francisco Bay, CA)," accepted for publication in *Continental Shelf Research*.

APPENDIX 2. Sequencing of Applied Studies, South Bay Salt Pond Restoration Project
Authors: Lynne Trulio, Lead Scientist, and Science Team
Dated: July 24, 2007

This memo provides an approach and rationale to sequencing the Applied Studies the Science Team has developed during the planning phase of the South Bay Salt Pond Restoration Project. Sequencing is important because, although all the studies we have identified are essential to the Project, some are on the critical path for research. This approach has three tiers:

Sequence 1 includes studies to be implemented at the beginning of Phase 1 or before, either because they address a direct threat to our ability to achieve Project Objectives, because Phase 1 provides ideal conditions to study the question, or the findings are essential to implementing future actions.

Sequence 2 includes studies to be initiated some time in Phase 1, but more fully in conjunction with future Project actions. Phase 1 conditions are not ideal for addressing these questions, but some data can begin to be collected in Phase 1.

Sequence 3 includes studies to be initiated after Phase 1 actions have been implemented and habitat has evolved or data from Sequence 1 studies have been collected.

Sequence 1: Studies to be implemented at the beginning of Phase 1 or before, as Phase 1 actions are conducive to answering these questions.

AS 5: **Will shallowly flooded ponds or ponds constructed with islands or furrows provide breeding habitat to support sustainable densities of snowy plovers while providing foraging and roosting habitat for migratory shorebirds?**

AS 6: **Will ponds reconfigured and managed to provide target water and salinity levels significantly increase the prey base for, and pond use by waterfowl, shorebirds and phalaropes/grebes compared to existing ponds not managed in this manner?**

AS 7: **To what extent will the creation of large isolated islands in reconfigured ponds maintain numbers (and reproductive success) of terns and other nesting birds in the South Bay, while increasing densities of foraging birds over the long term compared to ponds not managed in this manner?**

Rationale for AS 5, 6 and 7:

- The extent to which the current diversity and abundance of birds can be supported in a smaller footprint of actively managed ponds will be an important determinant in how much tidal marsh can be restored while still meeting Project Objectives. This information is critical for designing future Project actions.
- Conditions in Phase 1 are conducive to answering these questions as much of the Project area will still be managed ponds that can be manipulated to test the importance of different factors in attracting and supporting different bird species.

AS 11: **Will tidal habitat restoration and associated channel scour increase MeHg levels in marsh and bay-associated sentinel species?**

AS 12: **Will pond management increase MeHg levels in ponds and pond-associated sentinel species?**

Rationale for AS 11 and 12:

- Since the early stages of planning, the Project proponents have realized that Project actions have the potential to increase bioavailable mercury in the Bay. This issue has the potential to hinder the Project's ability to meet Project Objectives for sediment and water quality, and ecosystem health.
- There are major gaps in our understanding of this human and ecosystem-related issue and, as a result, research began in the planning stage. Studies continuing into Phase 1 will assess the effects of Project actions, both pond management and tidal restoration, on mercury uptake to the food web. Tidal restoration in A8 is being designed specifically to assess tidal restoration on mercury uptake.
- As part of the MeHg studies, data collection should begin on AS 2 (see Sequence 2 below). Pond A8 provides an ideal opportunity to study this question in sloughs.

AS 13a: **What is the effect of pond management on water quality and species both inside the ponds and outside in the sloughs and bay adjacent to pond discharge points?**

Rationale for AS 13a:

- Potential effects of operating the ponds under the Initial Stewardship Plan (ISP) have not been studied and little is known about the effects of pond management on conditions inside the ponds and directly outside. As a result, managers have had to deal with water quality problems since ISP management began. Lack of research on this topic could impede meeting Project Objectives for water quality and overall ecosystem health.
- Potential effects of pond management on entrainment of salmonids in ponds, pond discharges on receiving water species, and harbor seal populations, which are relevant to AS 10, should be studied in Phase 1.
- Understanding conditions created by pond management is of immediate importance in Phase 1 as most of the Project area will continue to be managed as ponds.

AS 15: **Will California gulls, ravens and crows adversely affect (through predation and encroachment on nesting areas) nesting birds in managed ponds and restored areas?**

Rationale for AS 15:

- The exponential increase in the California gull population in the South Bay is an immediate threat to Project Objectives focused on preserving nesting species and protecting listed species.
- An Adaptive Management Working Group for this issue has identified a number of studies that must be implemented before Phase 1 begins, as the Phase 1 actions will evict approximately 24,000 gulls from pond A6.

AS 17: **Will landside public access significantly affect birds or other target species on short or long timescales?**

AS 18: **Will public access features provide the recreation and access experiences visitors and the public want over short or long timescales?**

Rationale for AS 17 and 18:

- Two of the Project's missions to protect wildlife and enhance public access may be in conflict for some species and some types of access, and this issue is of great concern to stakeholders. Phase 1 includes an array of land-side public access elements, especially trails, near a range of habitats, which facilitates the study of land-side public access effects on wildlife.
- Adaptive Management for the Project includes a process for collecting and analyzing data on public access and wildlife interactions as well as on public satisfaction with access features. Collection of data is critical in Phase 1 since conclusions from the analysis will guide the type and amount of public access that could occur in Phase 1 and future phases.

AS 19: **Will voters, advocacy groups, elected officials, and government agencies support the project (especially in terms of funding) over the short timescale at the local and regional spatial scales?**

Rationale for AS 19:

- Funding is now, and will continue to be, a major challenge to implementing the Project and its adaptive management process. Money will need to come from a wide range of sources, including local residents, but we have little information on how to reach a range of constituents and secure their support. This may be one of the greatest threats to achieving the Project Objectives.
- By collecting this information in Phase 1, Project managers can design fund-seeking approaches that will provide money for future phases. Some approaches, such as ballot measures, will need significant time to develop and should be started as soon as possible.

Sequence 2: Studies to be initiated some time in Phase 1, but implemented more fully in conjunction with future Project Actions that better support addressing the questions.

AS 1: **Will sediment accretion in restored tidal areas be adequate to create and to support emergent tidal habitat ecosystems within the 50-yr projected time frame?**

AS 2: **Will sediment movement into restored tidal areas significantly reduce habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance in the South Bay?**

AS 3: **Will restoration activities always result in a net decrease in flood hazard?**

Rationale for AS 1, 2, and 3:

- Relatively little area will be opened to tidal action in Phase 1, which does not afford much opportunity to study these questions. One exception is opening A8 to tidal action, which affords an opportunity to collect data on AS 2 in sloughs. Future actions are expected to open large numbers of ponds along specific sloughs, which will provide optimal conditions for answering these questions, especially AS1 and 3.
- However, the Island Ponds and ponds open to tidal action in Phase 1 do allow initial study of these questions and research has begun, especially on AS1 and 3. Research conducted in Phase 1 will form the basis for research in future phases.

AS 14: **Where not adequately eradicated, does invasive *Spartina* and hybrids significantly reduce aquatic species and shorebird uses?**

Rationale for AS 14:

- This research depends on the results of the Invasive Spartina Project, which is currently in process. The results may not be known for some time. If the Invasive Spartina Project cannot control invasive *Spartina*, AS 14would become necessary.
- However, even now, the USGS is conducting research on the response of clapper rails to invasive and native *Spartina*. Any research conducted now will provide a basis for understanding species' responses to different types of habitats.

AS 16: **Will increases in boating access and boating behavior significantly affect birds, harbor seals, or other target species on short or long timescales?**

Rationale for AS 16:

- Relatively little in the way of improved boating access is planned in Phase 1, so this phase does not afford much opportunity to study this question.
- There is one kayak launch planned in Eden Landing that could be used, in combination with other South Bay kayak launches, as part of an initial study on this question.

Sequence 3: Studies to be initiated after Phase 1 actions have been implemented and habitat has evolved or data from Sequence 1 studies have been collected.

AS 4: **Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions?**

Rationale for AS 4:

- This question requires analysis of data collected from other studies, especially AS 5, 6, and 7, but also AS 8 and 9. Thus, this question cannot be addressed until a number of years of data have been collected, during Phase 1 and after.
- This question should be analyzed at regular intervals during the Project's lifetime, beginning in Phase 1, to determine the overall effect of the Project on South Bay birds.

AS 8: **Will pond and panne habitats in restored tidal habitats provide habitat for significant numbers of foraging and roosting shorebirds and waterfowl over the long term?**

AS 9: **How do clapper rails and other key tidal marsh species respond to variations in tidal marsh habitat quality and what are the habitat factors contributing to that response?**

Rationale for AS 8 and 9:

- Both questions involve determining species responses to vegetated tidal marsh conditions, which will take some time to evolve after Phase 1 tidal marsh actions are implemented.

- However, baseline data at appropriate reference sites can be collected in advance of tidal marsh evolving at the Phase 1 sites.

AS 10: **To what extent will increased tidal habitats increase survival, growth and reproduction of native species, especially fish and harbor seals?**

Rationale for AS 10:

- Response of non-avian species depends on tidal marsh evolution, which will take some time. During Phase 1, conditions will eventually change enough to potentially benefit native species survival, growth and reproduction. This study should be linked to the evolution of tidal habitat.
- However, even before marsh develops, baseline data on species use of managed ponds and the South Bay should be collected via Project monitoring and studied specifically as part of AS 13a.

AS 13b: **What are the effects of tidal habitat restoration on water quality, food web dynamics, and key components of the ecosystem such as phytoplankton, benthic invertebrates, or fish diversity and abundance in the South Bay and what factors result in these effects?**

Rationale for AS 13b:

- Response of the ecosystem and its components to restoration will depend on significant tidal marsh evolution. During Phase 1, conditions will eventually change enough to potentially affect ecosystem level components.
- However, even before marsh develops, baseline data on conditions in the South Bay ecosystem should be collected in order to assess the effects of restoration changes.

AS 20: **What are the costs and benefits associated with the Project sites and will they be shared equitably among communities, businesses, municipalities, and/or government agencies at local and regional scales?**

Rationale for AS 20:

- Monetizing Project actions standardizes the value of Project effects for clearer understanding by businesses, government agencies, and advocacy organizations (i.e., a dollar value is placed on the Project and its outcomes). The study would consist of analysis of current and projected economic conditions, estimates of Project costs (including actual construction and monitoring costs, but also potential social or health impacts), and projections of the economic benefits associated with Project activities.
- This study may be best implemented after some Project actions have occurred, allowing for public reaction. This study will provide data for Project Managers to educate the public about the benefits/needs/trade-offs associated with particular activities.

AS 21: **Will impacts associated with population growth and development adjacent to the Project sites and beyond be successfully managed over the long timescale at the regional scale**?

Rationale: for AS 21:

- Answering this question requires modeling to forecast social conditions around the Bay and the impacts of those conditions on the Project. This information will be most beneficial in later Project phases when landscape scale changes to the ponds occur. Those changes should occur in the context of predictions about impacts of future conditions, whether they be associated with climate change or the social fabric adjacent to the Project.
- However, developing this model should begin in conjunction with developing landscape scale hydrodynamic models, with the expectation of ultimately linking their predictions.

APPENDIX 3. Adaptive Management Summary Table

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
Sediment Dynamics Project Objective 1 (Preserve existing estuarine habitat areas)	No significant decrease in South Bay intertidal and subtidal habitats (south of San Bruno shoal), including restored pond mudflat, intertidal mudflat, subtidal shallow and subtidal channel areas.	▪ Area of restored mudflat. ▪ Area of outboard mudflat. ▪ Area of subtidal shallows and channel. Methods: Bathymetry and LiDAR surveys will be performed periodically, initially every 3–5 years and then less frequently if data suggest slower rates of changes over time.	▪ Change in tidal mudflat and subtidal shallows expected to vary at the pond complex scales. Areas will be estimated and reported on the pond complex scale. ▪ Changes in South Bay need to be placed within system-wide (San Francisco Estuary) context to assess influence of external factors.	▪ Change in tidal mudflat & subtidal shallow: 10–20 years, assuming significant tidal habitat restoration continues beyond Phase 1. ▪ Subtidal channel change: 0–5 years.	▪ Outboard mudflat decreases greater than the range of natural variability + observational variability/error.	▪ Will sediment movement into restored tidal areas significantly reduce habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance) in the South Bay? ▪ Development of a 2- and 3-D South Bay tidal habitats evolution model.	▪ Convene study session to review and interpret findings to assess if observed changes are due to restoration actions or system-wide changes in the sediment budget (*e.g.*, effects of sea level rise). ▪ Study biological effects of loss of mudflat, subtidal shallows, and/or subtidal channel habitat. ▪ Adjust restoration phasing and design to reduce net loss of tidal mudflats. Potential actions include remove bayfront levees to increase wind fetch and sustain tidal mudflat, phase breaching to match demand and supply, and/or breach only high-elevation ponds to limit sediment demand ▪ Reconsider movement up staircase
Sediment Dynamics Project Objective 1 (Rate of accretion indicates trajectory toward vegetated marsh)	Accretion rate of the restored ponds is sufficient to reach vegetation colonization elevations.	▪ Areas of inboard mudflat and pioneer marsh inside ponds ▪ Sedimentation rate inside breached ponds. Methods: Transects or SET in breached ponds, annually at first and then less frequently as rates of accretion slow. LiDAR surveys (see above).	▪ Pond scale	▪ 2–10 years depending on initial pond elevation	▪ Projections based on the rate of inboard mudflat accretion suggest vegetation colonization elevations are not likely to be achieved within the planning time frame.	▪ Will sediment accretion in restored tidal areas be adequate to create and to support emergent tidal marsh ecosystems within the 50-yr projected time frame?	▪ Convene study session to review findings to assess if observed changes are due to restoration actions and whether colonization is compromised. ▪ Study biological effects of slower tidal flat evolution. ▪ Adjust phasing and design to increase inboard mudflat accretion. Potential management actions include adding wave breaks or adding fill. ▪ Reconsider movement up staircase

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
Sediment Dynamics Project Objective 1 (Maintenance or increase of current vegetated marsh is essential to key species)	▪ No long-term net loss of vegetated tidal marsh throughout the South Bay.	Total area of tidal salt marsh Methods: Bathymetry and LiDAR surveys and/or Iconos satellite data and/or aerial photography and ground truthing	Pond Complex and South Bay	10 to 20 years	▪ Observed net loss of tidal salt marsh (area of outboard fringe marsh losses > greater area of tidal marsh in restored ponds) than the range of natural variability + observational variability/error.	▪ Will sediment accretion in restored tidal areas be adequate to create and to support net increase in emergent tidal marsh habitat within the 50-yr projected time frame? ▪ Development of a 2- and 3-D South Bay tidal habitats evolution model	▪ Convene study session to review findings to assess if observed changes are due to restoration actions. ▪ If tidal marsh area is not meeting projections, assess biological significance of long-term loss of tidal marsh. ▪ Adjust phasing and design to accelerate marsh development. Potential management actions include filling to colonization elevations, adding wave breaks and/or preserving bayfront levees ▪ Adjust phasing and design to reduce erosion of existing marsh. For example, phase tidal restoration to match sediment demand and supply.
Flood Protection Project Objective 2	▪ No increase in tidal or fluvial flood risk at any project phase and improve tidal and fluvial flood protection in the South Bay in specific areas	▪ Survey slough channel cross-sections (scour) in the vicinity of breaches; ▪ Survey marshplain accretion in the ponds; initially frequently, then less often ▪ Measure water surface elevations inside the ponds and in the sloughs in the vicinity of breaches; initially annually, then less frequently ▪ Collect high water mark elevations in the vicinity of breaches and upstream, following large flood events ▪ Inspect for levee erosion initially monthly, then annually, and after major rainfall and/or tidal events ▪ Monitor relative sea level rise (sea level rise and land subsidence) every few years ▪ Water levels and cross-sections upstream in flood-prone channels	Slough (drainage) scale	▪ Slough channel cross-sections, marshplain accretion, and water levels: rapid initial response (within approximately five years) followed by slower changes over decades. ▪ Flood high waters: approximately every ten years (depends on timing of large events) ▪ Levee erosion: same timeframe as channel cross-section and marshplain accretion responses above, or as dictated by rainfall, tidal, and other events. ▪ Relative sea level rise: approximately ten years or longer	▪ Flood modeling predicts a current or future increase in flood risk (*e.g.*, decrease in levee freeboard). ▪ Significant levee erosion observed ▪ Elevated water surface elevations projected by modeling effort and/or observed in the field ▪ Field data collection and/or observation indicates that flood risk is greater than that predicted by models (*e.g.*, water surface elevation is higher)	Will restoration activities always result in a net decrease in flood hazard?	▪ Adjust phasing and design to provide fluvial flood protection. For example, set back or lower additional levees to increase flood conveyance or dredge channels. ▪ Adjust phasing and design to protect levees. For example, adjust levee maintenance or implement levee improvements (*e.g.* widen shoulder, raise, armor, set back levee)

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
Water Quality Project Objective 4	▪ Water quality parameters in ponds will meet RWQCB standards ▪ South Bay water quality will not decline from baseline levels ▪ DO levels meet Basin Plan Water Quality Objectives	▪ Water quality parameters (DO, pH, suspended sediment and turbidity, trace contaminants other than mercury, etc.) set by RWCQB in ponds and Bay (methods as per Takekawa, et al. 2005). ▪ Sediment oxygen demand ▪ Continue as is under regulatory requirements for managed ponds. ▪ Relate to RMP for conventional pollutants (Use RMP infrastructure for Far South Bay main water mass.) ▪ Relate to RMP for trace contaminants (Use RMP process for determining frequency and methods for Far South Bay main water mass. Also use RMP process for determining need for and frequency of tidal habitat special studies.)	Ponds, receiving waters, and entire South Bay	Ongoing	▪ Annual data review to determine variation from past trends ▪ Review of RMP results indicate abnormal conditions ▪ Other indication of abnormal conditions such as fish kills ▪ Increases in chlorophyll-a to levels indicating eutrophic conditions ▪ Increases in sediment oxygen demand to levels indicating risk of low DO ▪ Low dissolved oxygen in ponds or receiving waters	▪ What is the effect of a) pond management, including increased pond flows and associated managed pond effects, and b) increased tidal prism from tidal marsh restoration on water quality, phytoplankton and fish diversity and abundance, and food web dynamics in South Bay? ▪ Can residence time be altered to prevent low dissolved oxygen? ▪ Is it possible to re-aerate water prior to discharging to the Bay? ▪ What effect would progress all the way to 90/10 (Alternative C) have on the BOD loading to the Bay?	▪ Applied studies to find causes of water quality problems in ponds (need salinity, temperature, wind speed, solar radiation, sediment oxygen demand, and net primary production) ▪ Applied studies of Bay-wide conditions ▪ Applied studies of WQ effects on pond/Bay species (plankton, shrimp, fish, birds) ▪ Active management such as baffles, aerators, etc. ▪ Decrease number of ponds monitored as conversion away from managed ponds to full tidal occurs. Focus on managed ponds with compliance issues. ▪ Review all available data. ▪ Reduce pond residence times. ▪ Accelerate conversion from managed ponds to tidal habitat. ▪ Eliminate managed pond discharges by converting to seasonal wetlands. ▪ Decrease pond residence time ▪ Introduce re-aeration mechanisms at discharge points ▪ Reconsider movement up staircase
Mercury Project Objective 4	▪ Levels of Hg in sentinel species do not show significant increases over baseline conditions ▪ Levels of Hg in sentinel species are not higher in target restoration habitats than in existing habitats	Hg levels in sediment, water column and sentinel species (methods as per Collins, et al. 2005)	Ponds and pond complexes	1–3 years depending on specific data and overall geographic scope	▪ One or more sentinel species show higher levels of Hg in target habitats than existing habitats ▪ One or more sentinel species show higher than ambient levels of Hg in Pond A8 or Alviso Slough.	▪ Will tidal marsh restoration and associated channel scour increase methylmercury (MeHg) levels in marsh and bay-associated sentinel species? ▪ Will pond management increase MeHg levels in ponds and pond-associated sentinel species?	▪ Applied study of sources of Hg and causes of increases ▪ Applied study of sediment capping methods (if relevant) ▪ Applied study of methylation processes (*e.g.*, photo-degradation, microbial methylation) ▪ Adjust phasing and design; for example, undertake preventative dredging or prevent draining of interstitial spaces or pore water. ▪ Reconsider opening more Alviso ponds to tidal action.

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
Algal composition and abundance	▪ Nuisance and invasive species of algae are not released from the Project Area to the Bay. ▪ Algal blooms do not cause low DO within managed ponds	Algal species – visual observations of macrophytes and plankton tows Chlorophyll-a Sediment oxygen demand (SOD)	Ponds (visual), Bay (plankton tows) Ponds	Annually Annually	▪ Nuisance macrophytes are observed ▪ Harmful exotic species of phytoplankton are characterized in Bay	▪ Does pond configuration affect algal composition and abundance? ▪ Do harmful exotic species of algae persist in the Bay?	▪ Alter pond configuration ▪ Introduce artificial shading ▪ Stop progression towards Alternative C
Tidal Marsh Habitat Establishment Project Objective 1A	▪ Tidal marsh vegetation/habitat mosaic (including vegetation acreage and density, species composition, acreage of mudflat, channels, marsh ponds and transition area) is on a trajectory toward a reference marsh and/or other successful marsh restoration sites in South San Francisco Bay.	▪ Tidal marsh habitat acreage (*e.g.*, vegetation, mudflat, channel, pan, transition zones, etc.; collected via remote imagery with limited ground-truthing) as a percent of the total restoration area; plant species composition, including abundance of non-natives such as non-native *Spartina* spp. (qualitative assessments for invasive species will occur annually, quadrant or transect sampling once marsh has 20% vegetation cover); habitat trajectory toward a reference marsh and other restoration sites ▪ Tidal marsh habitat quality rated as high, medium, or low based on usefulness to clapper rail and salt marsh harvest mouse, determined every 2-3 years using aerial photos and ground-truthing ▪ Habitat mapping will take place every 5 years, beginning 5 years after the restored area has reached vegetation colonization elevation. Once 40% native vegetation cover has been achieved, species composition will be collected (in years corresponding to the habitat mapping) in a variety of zones (low marsh, high marsh, upland transition) within each restored marsh. (It would be beneficial to have increased frequency of	Entire South Bay	Establishment depends on initial pond elevation, vegetation colonization anticipated to be detectable within 5 years (or less) of reaching appropriate elevations, while habitat development trajectory anticipated to be detectable within 15 years (and possibly less) of the onset of vegetation colonization	▪ Vegetation deviates significantly (30–50%) from projected trajectory after colonization elevations are achieved. ▪ Channel and marsh pond formation does not occur as predicted. ▪ Non-native *Spartina* present on the site.		▪ Review sediment dynamics ▪ Study causes of slow vegetation establishment and channel development (ex: gypsum) ▪ Active revegetation ▪ Increased non-native invasive species control ▪ If invasive species cannot be controlled, study biotic response to non-native vegetation ▪ Continue to re-evaluate what is meant by "control" of invasive species and adjust monitoring and management triggers based on the latest scientific consensus ▪ Adjust phasing and design ▪ Reconsider movement up staircase

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
		monitoring in the early Project phases.)					
Vector Control Project Objective 5	▪ The need for mosquito control does not exceed NEPA/CEQA baseline as determined by the Vector Control agencies	▪ Presence/absence of mosquitoes in former salt ponds ▪ Number of acres of breeding mosquitoes ▪ Number of larvae/dip in potential breeding habitat ▪ Number of acres within the Project Area treated for mosquitoes ▪ Costs/level of effort (*e.g.*, hours spent in treatment, amount of material applied, helicopter cost, etc.) to control mosquitoes	Focal areas that may support mosquito sources throughout the South Bay	Ongoing	▪ Detection of breeding mosquitoes in a former salt pond ▪ Detectable increase in monitoring parameters (relative to NEPA/CEQA baseline), particularly in areas with human activity/exposure ▪ Detection of mosquitoes that are known disease vectors and/or are of particular concern (*i.e.*, *Aedes squamiger*, *A. dorsalis*) in the Project Area		▪ Adjust design to enhance drainage or tidal flushing, control vegetation in ponded areas, and/or facilitate access (for control) to marsh ponds ▪ Increase level of vector control (preferably only as an interim measure while design issues are addressed to reduce mosquito breeding habitat) ▪ Study relationships of fish abundance and community composition and mosquito larval abundance in marsh features (*e.g.*, ponds and pannes) and managed ponds ▪ Ensure management actions are consistent with Refuge mosquito management policies
Clapper Rails Project Objective 1A	▪ Meet recovery plan criteria for clapper rail habitat within the SBSP Restoration Project Area	Clapper rail tidal salt marsh habitat acreage, quality (see Tidal Marsh Habitat Establishment above)	Entire South Bay	Likely decades for high-quality tidal marsh development (10-year targets)	See triggers for *Sediment Dynamics*, *Vegetation Establishment* above	▪ How do clapper rails and/or other key tidal marsh species respond to variations in tidal marsh habitat quality and what are the habitat factors contributing to that response?	▪ See *Vegetation Establishment* above ▪ Reconsider movement up staircase
	▪ Meet recovery plan criteria for clapper rail numbers (0.25 birds/ac over 10-year period) within the SBSP Restoration Project Area	Winter numbers, censused during high-tide airboat surveys, and breeding-season numbers, censused at representative locations	Entire South Bay	Monitoring not expected to show substantial results until 5–10 years after cordgrass establishment in 300 acres or more (10-year targets)	▪ Numbers drop below 0.20 birds/ac in any given year for Project Area as a whole ▪ Rate of increase in clapper rail numbers deviates significantly from projection		▪ See *Vegetation Establishment* above ▪ Applied studies of habitat parameters, contaminant levels, and predation pressure related to rail densities and productivity (and implement related management actions as appropriate) ▪ Reconsider movement up staircase
Salt Marsh Harvest Mice Project Objective 1A	▪ Meet recovery plan criteria for salt marsh harvest mouse habitat within the SBSP Restoration Project Area	Salt marsh harvest mouse tidal salt marsh habitat acreage, quality (see Tidal Marsh Habitat Establishment above)	Entire South Bay	Likely decades for high-quality tidal marsh development (10-year targets)	See triggers for *Sediment Dynamics*, *Vegetation Establishment* above	▪ How do salt marsh harvest mice and/or other key tidal marsh species respond to variations in tidal marsh habitat quality and what are the habitat factors contributing to that response?	▪ See *Vegetation Establishment* above ▪ Adjust phasing and design; for example, add or enhance upland transition habitat within and between restored marshes ▪ Reconsider movement up staircase

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
	▪ 75% of viable habitat areas within each large marsh complex with a capture efficiency level of 5.0 or better in five consecutive years	Capture efficiency (targeting multiple areas with a CE of at least 5.0)	Entire South Bay	Monitoring not expected to begin for 5–10 years after pickleweed establishment in 300 acres or more	Rate of increase deviates significantly from projection		▪ See *Vegetation Establishment* above ▪ Adjust phasing and design; for example, add or enhance upland transition habitat within and between restored marshes ▪ Reconsider movement up staircase
Migratory Shorebirds Project Objective 1B	▪ Maintain numbers of migratory shorebirds at pre-ISP baseline numbers, if known, or as close to that baseline as can be determined.	▪ Use previously collected data (USGS, PRBO, SFBBO) on foraging shorebird densities, as well as modeled densities, to set targets for densities of foraging shorebirds for each restored/managed habitat type (*e.g.*, reconfigured ponds and restored mudflats) by season. Targets would be based on densities (by habitat type and/or geographic area) necessary to maintain pre-ISP numbers. Conduct limited surveys in a sample of habitats/locations within the SBSP Restoration Project Area to estimate foraging densities. ▪ Use existing data from Flyway Project surveys and data from initial few years of window surveys to determine the percentage of small migratory shorebirds that occur in the South Bay compared to the entire Bay. Monitor abundance in fall, winter, and spring via high-tide, baywide “window” surveys (in which multiple observers census a number of locations in a brief [*e.g.*, 3-day] period) conducted throughout San Francisco Bay. SBSP Restoration Project would provide for the coordination of these surveys.	▪ Monitoring stations in a sample of habitats/locations within the SBSP Restoration Project Area (for collection of data on shorebird densities in various habitats) and throughout the Bay Area (for collection of data on the percentage of small migratory shorebirds that occur in the South Bay compared to the entire Bay)	▪ Changes in shorebird foraging densities are expected to be immediate upon changes in management (*e.g.*, reconfiguration and management of a pond for optimal foraging depths, or conversion of a salt pond bottom to intertidal mudflat upon breaching of levees), although any changes in densities within a given habitat type will be slower. ▪ May take years or decades for the percentage of S.F. Bay birds using the South Bay to change in response to SBSP Restoration Project.	▪ Three consecutive years in which observed densities of foraging shorebirds for selected habitat types are below targets. ▪ Three consecutive years in which the percentage of S.F. Bay small migratory shorebirds that use the South Bay is below the baseline (as determined using window survey data).	▪ Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions? ▪ Will ponds reconfigured and managed to provide target water and salinity levels significantly increase the prey base for, and pond use by waterfowl, shorebirds and phalaropes/grebes compared to existing ponds not managed in this manner? ▪ To what extent will the creation of large isolated islands in reconfigured ponds maintain numbers (and reproductive success) of terns and other nesting birds in the South Bay, while increasing densities of foraging birds over the long term compared to ponds not managed in this manner? (including studies of mudflats and managed ponds invertebrate productivity, time-energy budgets for foraging birds, relative importance of and prey use in ponds with different salinities) ▪ Will intramarsh pond and panne habitats in restoring tidal marshes provide habitat for significant numbers of foraging and roosting shorebirds and waterfowl?	▪ Analyze all available monitoring data for South Bay, Bay Area, and entire Pacific Flyway to determine whether declines are likely the result of SBSP Restoration Project, or the result of external factors. Coordinate with other Pacific Flyway studies; develop the larger structure for a centralized flyway monitoring network. ▪ Conduct Bay-wide survey to determine whether Project has displaced birds to other areas ▪ If declines are likely the result of SBSP Restoration Project: – Adjust design, for example reconfigure more ponds for use by foraging shorebirds – Adjust management, for example, manage more ponds for optimal water levels and salinities for foraging shorebirds ▪ Reconsider movement up staircase

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
Breeding Avocets, Stilts, and Terns Project Objective 1B	▪ Maintain numbers and breeding success of breeding avocets, stilts, and terns using the South Bay at pre-ISP baseline numbers, if known, or as close to that baseline as can be determined.	▪ Monitor total numbers of nesting Forster's and Caspian terns in the South Bay via comprehensive breeding-season surveys (per methods currently employed by SFBBO). Baseline has been established through past/ongoing monitoring conducted by SFBBO. ▪ Sample selected areas within the South Bay during the breeding season to determine the numbers of stilt/avocet nests in those areas. ▪ Estimate reproductive success by sampling a subset of breeding locations/colonies.	▪ Local (pond-level) scale for management actions, such as island creation, at specific ponds ▪ Entire South Bay for estimates of numbers (with estimates of breeding success in a few representative areas)	▪ Immediate response (increase) expected due to Phase 1 actions ▪ Longer-term trends monitored annually	▪ Decline in numbers (in the South Bay as a whole) or reproductive success of breeding stilts, avocets, and Forster's and Caspian terns below baseline for two consecutive years	▪ Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions? ▪ To what extent will the creation of large isolated islands in reconfigured ponds maintain numbers (and reproductive success) of terns and other nesting birds in the South Bay, while increasing densities of foraging birds over the long term compared to ponds not managed in this manner? (including predation and predator control studies, vegetation management approaches and Hg uptake in eggs, and related toxicity studies) ▪ Will California gulls, ravens, and crows adversely affect (through predation and encroachment on nesting areas) nesting birds in managed ponds?	▪ Analyze all available monitoring data for South Bay, Bay Area, and entire Pacific Flyway to determine whether declines are likely the result of SBSP Restoration Project, or the result of external factors (taking into account the downward trends in abundance of Forster's terns over last few decades, which are unrelated to salt pond conversion). ▪ If declines are likely the result of SBSP Restoration Project: - Undertake applied studies of habitat parameters, contaminant levels, prey availability and type, juxtaposition of nesting and brood rearing/foraging areas, predation pressure, and disturbance to determine appropriate design/management adjustments - Conduct Bay-wide survey to determine whether SBSP Restoration Project has simply displaced birds to other Bay-area locations. - Adjust design to construct more, or more optimal, nesting islands - Adjust design to reduce Hg uptake - Adjust management. For example, manage more ponds for optimal water levels and salinities for breeding and foraging stilts and avocets, manage more ponds for optimal water depths and salinities for foraging terns and/or control predation, vegetation, human disturbance. ▪ Reconsider movement up staircase

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
Diving Ducks Project Objective 1C	▪ Maintain numbers of diving ducks using the South Bay at pre-ISP baseline numbers	Use mid-winter waterfowl survey data to monitor winter numbers of diving ducks in the South Bay. Baseline has been set by previous mid-winter surveys and Accurso's studies.	Entire South Bay	Local changes in abundance are expected to be immediate upon changes in management (*e.g.*, reconfiguration and management of a pond, or conversion of a salt pond bottom to intertidal mudflat upon breaching of levees). Larger-scale changes in abundance will likely be slower (on the order of years to decades).	Decline in South Bay numbers below baseline conditions for two consecutive years	▪ Will sediment movement into restored tidal areas significantly reduce habitat area and/or ecological functioning (such as plankton, benthic, fish or bird diversity or abundance in the South Bay? ▪ Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions? ▪ Will intramarsh pond and panne habitats in restoring tidal marshes provide habitat for significant numbers of foraging and roosting shorebirds and waterfowl over the long term?	▪ Analyze all available monitoring data for South Bay, Bay Area, and entire Pacific Flyway to determine whether declines are likely the result of SBSP Restoration Project, or the result of external factors ▪ If declines are likely the result of SBSP Restoration Project: - Undertake applied studies of habitat use and effects of human disturbance to determine appropriate design/management adjustments - Adjust design to increase the restoration of shallow subtidal habitat - Adjust management. For example, manage more ponds for optimal water depths and salinities for foraging diving ducks and/or control human disturbance ▪ Reconsider movement up staircase
Salt Pond Associated Migratory Birds (Wilson's and Red-necked Phalaropes, Eared Grebes, Bonaparte's Gulls) Project Objective 1B	▪ Maintain these species' use of SBSP Restoration Project Area ▪ Minimize declines in the South Bay relative to pre-ISP baseline	Focused surveys would be conducted targeting seasonal peaks (*i.e.*, late summer/early fall for phalaropes, fall and winter for Eared Grebes and Bonaparte's gulls) and geographic concentrations (*e.g.*, high-salinity ponds and other areas known to support large proportions of South Bay numbers of these species) to determine the numbers of these species using the South Bay.	Entire South Bay (as determined by surveys in areas where these species are concentrated)	Local changes in abundance are expected to be immediate upon changes in management (*e.g.*, reconfiguration and management of a pond, or conversion of a salt pond bottom to intertidal mudflat upon breaching of levees). Larger-scale changes in abundance will likely be slower (on the order of years to decades).	Three consecutive years in which numbers are more than 25% below the NEPA/CEQA baseline, or any single year in which numbers are more than 50% below NEPA/CEQA baseline	▪ Will the habitat value and carrying capacity of South Bay for nesting and foraging migratory and resident birds be maintained or improved relative to current conditions? ▪ Will ponds reconfigured and managed to provide target water and salinity levels significantly increase the prey base for, and pond use by waterfowl, shorebirds and phalaropes/grebes compared to existing ponds not managed in this manner?	▪ Analyze all available monitoring data for South Bay, Bay Area, and entire Pacific Flyway to determine whether declines are likely the result of SBSP Restoration Project, or the result of external factors (taking into account declines that have already occurred due to ISP). ▪ If declines are likely the result of SBSP Restoration Project: - Adjust management to have more ponds with optimal water levels and salinities for foraging pond-associated birds ▪ Reconsider movement up staircase

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
Western Snowy Plovers Project Objective 1A	▪ Contribute to the recovery of the western snowy plover by providing habitat to support 250 breeding birds within SBSP Restoration Project Area, and maintain a 5-year average productivity level as required by the Recovery Plan.	Snowy plover numbers and estimated nest success, determined through comprehensive, annual South Bay surveys and monitoring during the breeding season	Entire South Bay for estimates of numbers (with estimates of breeding success in a few representative areas)	Local changes in abundance are expected to be immediate upon changes in management (*e.g.*, reconfiguration and water level/prey management of ponds). Longer-term trends will be monitored annually.	▪ Rate of population change declines substantially from projected trajectory toward target ▪ South Bay population declines in any given year below 2006 baseline	Will shallowly flooded ponds or ponds constructed with islands or furrows provide breeding habitat to support sustainable densities of snowy plovers while providing foraging and roosting habitat for migratory shorebirds compared to existing ponds not managed in this manner? (including predation studies and predator control studies, vegetation management approaches, and Hg- related toxicity studies	▪ Analyze all available monitoring data for South Bay, Bay Area, and entire Pacific Flyway to determine whether declines are likely the result of SBSP Restoration Project, or the result of external factors (taking into account the downward trends in abundance of plovers over last few decades, which are unrelated to salt pond conversion). ▪ If declines are likely the result of SBSP Restoration Project: – Undertake applied studies of habitat parameters, contaminant levels, prey levels/type, juxtaposition of nesting and brood rearing/foraging areas, predation pressure, and disturbance to determine appropriate design/management adjustments – Adjust design to construct more, or more optimal, nesting habitat, create more open salt panne habitat, and/or to reduce Hg uptake – Adjust management of water levels and salinities in more ponds for optimal breeding and foraging habitat and/or control predation, vegetation, human disturbance ▪ Reconsider movement up staircase
California Least Terns	▪ Maintain numbers of post-breeding California least terns in the Project Area at multi-year average levels including natural variation in numbers; avoid negative effect of SBSP Restoration Project on Bay-area least tern breeding bird numbers (multi-year average	Counts of birds using the South Bay as a post-breeding foraging area (or breeding area, if that occurs) and breeding pairs at Bay-area nesting colonies	Post-breeding foraging sites and breeding colonies	Local changes in abundance may be immediate upon changes in management (*e.g.*, reconfiguration and management of a pond, or conversion of a salt pond bottom to intertidal mudflat upon breaching of levees). Larger-scale changes in abundance will likely be slower (on the order of years to decades).	Decline in total number of birds using the South Bay as a post-breeding foraging area or breeding pairs in the S.F. Bay Area below 2006 baseline levels, in any given year		▪ If numbers decline, first use available information to attempt to determine whether declines are resulting from SBSP Restoration Project or other factors (*e.g.*, the impact of South Bay California gulls on nesting colonies or changes in Bay fisheries). ▪ Conduct applied study of post-breeding habitat use and diet, especially in the South Bay. ▪ Implement management or adjust design (*e.g.*, if applied study finds

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
	levels with natural variation)						more foraging occurs in ponds than Bay, manage more ponds for suitable least tern foraging conditions). ▪ Reconsider movement up staircase.
Steelhead Project Objective 1C	▪ Enhance numbers of salmonids and juvenile in rearing and foraging habitats relative to NEPA/CEQA baseline numbers	Counts of upstream-migrating salmonids to monitor spawning populations in South Bay streams	South Bay spawning streams	5–10 years likely for effects of restoration on salmonids to be detectable	Reduction in number of upstream-migrating salmonids	Will increased tidal habitat increase native fish and harbor seal survival, growth and reproduction? (including specific study of steelhead)	▪ If numbers decline, first use available information to attempt to determine whether declines are resulting from SBSP Restoration Project or other factors (*e.g.*, factors associated with spawning streams). ▪ Conduct applied study of constraints to population growth (ex: Hg, water quality, food chain). ▪ Conduct applied study of condition of salmonids seaward of restoration site (sample Chinook using minnow net upstream from, at, and downstream from restoration sites before and after restoration; determine whether fish are larger and healthier after than before restoration). ▪ If numbers decline, conduct diet studies on piscivorous birds (to determine whether increased bird predation is responsible). ▪ Implement management or adjust design (*e.g.*, restore more tidal habitat adjacent to spawning streams). ▪ Reconsider movement up staircase.
Estuarine Fish Project Objective 1C	• Enhance numbers of native adult and juvenile fish in foraging and rearing habitats relative to NEPA/CEQA baseline numbers	▪ Presence/abundance of surfperch in restored marshes (as measured in permanent monitoring locations with pilings installed to facilitate monitoring) ▪ Presence/ absence of native flatfish, such as starry flounder, in restored un-vegetated shallow water areas ▪ Species richness and	Monitoring results will reflect conditions at monitoring stations scattered throughout the SBSP Restoration Project Area, in tidal habitat, ponds, and sloughs	Varies by trigger – ▪ fish are expected to move into newly restored areas almost immediately but assemblages will change as habitat matures ▪ surfperch not expected to use restored marshes until vegetation is established ▪ negative impacts may be immediate if poor water quality from a pond	▪ Detection of a fish die-off ▪ Absence of detections of surfperch using restored tidal marsh ▪ Increase in percent of individuals sampled in restored marshes that are non-native ▪ Detectable reduction in water quality (as determined by monitoring described under “Water Quality” Key	Will increased tidal habitat increase native fish abundance and will restored habitat support healthy populations? (including specific study of native estuarine fish)	▪ Use available information to attempt to determine whether declines are resulting from SBSP Restoration Project or other factors (*e.g.*, factors associated with spawning streams). ▪ Applied study of constraints to population growth (ex: Hg, water quality, food chain) ▪ If fish populations decline, conduct diet studies on piscivorous birds (to determine whether increased bird predation

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
		abundance of native fish species in a range of habitats including restored marshes and associated unvegetated shallow water areas, major and minor sloughs, and deep and shallow-water ponds ▪ Water quality parameters (see "Water Quality" Key Category)		discharge causes a die-off	Category) ▪ Deviation from expected trajectory of native fish use of restored marshes and associated unvegetated shallow water areas		is responsible). ▪ Consider possible effects of recreational angling pressure. ▪ Implement management or adjust design (*e.g.*, remove more levees to increase connectivity in restored ponds) based on study results ▪ Reconsider movement up staircase
Harbor Seals Project Objective 1C	▪ Maintain or enhance numbers of harbor seals using the South Bay	▪ Conduct periodic monitoring at known South Bay haul-out sites (*e.g.*, Mowry, Newark & Alviso Sloughs, and expand to include haul-out site in Corkscrew Slough) to determine trends in productivity and abundance, and changes in distribution. If incidental sightings at other areas are not adequate to determine if new haul-out sites are established, periodically survey other locations as well. Existing data include over 5 years of weekly survey data for Mowry and Newark sloughs, and 5 years of monthly survey data for Alviso Slough. ▪ Mercury parameters (see "Mercury" Key Category)	Focal areas (*i.e.*, known haul-out sites) throughout South Bay	Negative response to human disturbance from improved public access may be immediate; response to habitat restoration or increased mercury availability may be longer-term (a decade or more)	▪ Decline in overall South Bay numbers and pup production, if known, at haul-out sites below 2006 baseline levels for 2 consecutive years ▪ Reduction in frequency of use and pup production, if known, of Mowry Slough and adjacent haul-out/pupping areas	▪ Will increased tidal habitat increase native fish and harbor seal survival, growth and reproduction? ▪ Will increases in boating access significantly affect birds, harbor seals or other target species on short or long timescales?	▪ See management actions under "Mercury" and "Public Access" Key Categories ▪ Other potential management actions may include: - Restrict public access and/or improve public education near seal haul-out sites - Create seasonal closure in areas that might be appropriate for seal protection during pupping season, including buoys restricting access to sloughs to boats and land-based trails. - Enforce protective measures such as increased patrolling etc. ▪ If seal populations decline or pupping rates decline, conduct studies on seal health (pollutant exposure), potential disturbance changes, habitat/prey alternations (fish declines or fish community changes), or reduced access to sites due to steep gradient, tidal restrictions, or insufficient deep water
Public Access Project Objective 3	▪ High quality visitor experience is maintained ▪ Facilities are not degraded by over usage	▪ Visitor use surveys (numbers, activities, demographics, overall experience and peak use (surveys yearly) ▪ Staff observations ▪ Complaints or compliments registered with land managers ▪ Cost of maintaining facilities	Within the Project Area.	Based on construction of facilities and public use (5+ years of usage)	▪ Survey results show dissatisfaction ▪ Overcrowding at staging areas ▪ Conflicts between users (recorded incidences) ▪ Maintenance costs exceed budget	▪ Will public access features provide the recreation and access experiences visitors and the public want over short or long timescales? (Study visitor traits and use patterns, visitor satisfaction with experience, public demand for other uses, facility degradation)	▪ Adjust design. For example, limit number of visitors to a given area, provide alternate use times for certain activities and/or reduce development of some uses, increase others, based on demand. ▪ Hold public meetings/workshops to inform the public of applied studies findings to determine how best to meet public recreation

APPENDIX 3. Adaptive Management Summary Table (Continued)

CATEGORY/ PO	RESTORATION TARGET	MONITORING PARAMETER (METHOD)	SPATIAL SCALE FOR MONITORING RESULTS	EXPECTED TIME FRAME FOR DECISION-MAKING	MANAGEMENT TRIGGER	APPLIED STUDIES	POTENTIAL MANAGEMENT ACTION
							desires given specific problems ▪ Hold charrette (group design process over 1-day)
Public Access Project Objective 1A, B, C	▪ Public use does not prevent reaching restoration targets as measured by significant impacts to target species.	Numbers, species richness and behavior of target species in public access areas	Within the Project Area, except as noted in restoration targets for shorebirds, diving ducks, breeding birds, California clapper rail, Western snowy plovers, and harbor seals.	Some parameters are immediate (*i.e.*, behavior); others may take 3 years or much more	▪ For species or guilds without specific population targets: statistically significant abundance, species richness or behavioral changes compared to control sites ▪ For species with population targets: reduction in abundance or density of breeding and/or non-breeding animals due to public access	▪ Will landside public access significantly affect birds or other target species on short or long timescales? (including studies of waterfowl, clapper rail and snowy plover responses to public access, and roosting bird response to public access) ▪ Will increases in boating access significantly affect birds, harbor seals or other target species on short or long timescales? (including studies of waterbird response to boaters)	▪ Adjust design. For example, provide edge condition to prevent visitors from moving off-trail (*e.g.*, fencing). change design to reduce wildlife disturbance based on study findings, or, in sensitive areas, restrict public access and redirect. ▪ Increase public access if species goals are met, but continue to monitor species' response ▪ Evaluate changes in population or density of species with population targets in light of restoration targets and other impacts on the species ▪ Design future phases to avoid significant impacts to species and optimize public access in areas of little or no species impact

APPENDIX 4.
Suggested Proposal Solicitation and Directed Studies Processes

PART 1. PROPOSAL SOLICITATION

Calls for Proposals
The Science Program managers will direct the process for developing questions for study. When the list of approved applied study questions has been developed, the science managers and PMT will develop one or more competitive calls for proposals designed to solicit proposals from as wide a pool of respondents as possible. The call for proposals will be reviewed by the appropriate management and technical oversight bodies. The sponsoring agencies will also publicize the criteria to be used in proposal evaluation (see draft list below).

Pre-Proposals. In order to reduce the necessity for a large number of proponents to expend much effort in developing proposals that are eventually not funded, the Project's science managers will require that all proposals be preceded by a brief pre-proposal. Pre-proposals will be reviewed by the sponsoring agency staff, PMT, and the Science Program managers to ensure that the proposed work is responsive to the call for proposals, that the proposed work has apparent scientific merit, and that the funding request seems reasonable.

Proposals. For those selected pre-proposals, researchers will submit a proposal study plan that contains sufficient information to allow for technical and statistical evaluation by peer reviewers, including details about experimental design, field and laboratory procedures, data collection, and quantitative methods. The following format is recommended:

1. *Cover sheet* – A transmittal document that includes the call for proposals number and date; the title of the proposal; a brief statement of the purpose and objectives of the proposed study; the total funding requested by year; the name and home institution(s) of the PIs and Co-PIs; the name of the institution's Grant Administrator; the applicant's tax status; and dated signature lines for the Principal Investigator(s) and the institutional representative.
2. *Abstract* – A brief, topical abstract (200 words or less).
3. *Background and justification* – Statement of the problem(s) being addressed, hypotheses being tested, information needed, and relationship/relevance of the problem(s) being addressed to other South Bay Salt Pond Restoration Project projects or sponsoring agency projects and programs, with reference to appropriate literature citations regarding the problem(s).
4. *Study Objectives* – Description of the planned outcome of the study
5. *Study area(s)* – Description of the study location, i.e., whether it is a field and/or laboratory study. A field study proposal should include clear identification and description of the study sites, with a map.
6. *Approach* – Description of the study approach, with sampling and analytical procedures clearly described for each objective. Include details on methods/techniques, equipment and facilities, data collection, statistical analysis and quality assurance procedures, and describe the criteria to be used in hypothesis testing.

7. *Data archiving procedures* – Description of how the data will be handled, stored, and made accessible. All data collected under the auspices and funding of the South Bay Salt Pond Restoration Project will be made accessible through a Project database and website.
8. *Work Schedule* – An annual time line with expected start and stop dates, and accomplishment of major milestones.
9. *Hazard assessment/safety certification* – Identification of anticipated hazard or safety concerns affecting project personnel (e.g. aircraft, off-road vehicles, chemicals, and extreme environmental conditions).
10. *Permission to access CA Department of Fish & Game and US Fish & Wildlife Service lands* – Documentation of permission to access government property for purposes of conducting research and monitoring, or documentation that permission will be granted if funding is provided.
11. *Animal care and use certification* – Discussion of anticipated uses of animals in the research, including copies of approved forms for animal care and use. If animals are not to be used, collected, manipulated, or experimented upon, include a specific statement to the fact that no animals will be used in the research.
12. *Expected product(s)* – List of planned publications, reports, presentations, advances in technology, information transfer at workshops, seminars, or other meetings.
13. *Qualifications of Investigators, partnerships, and cooperators* – Brief resumes (two pages) of the principle investigators that include descriptions of the qualifications of principal personnel, identification of affiliations, expected contributions to the effort, including logistical support, and relevant bibliographic citations.
14. *Budget and staff allocations* – Detailed budget including salaries and benefits for each participant and costs for travel, equipment, supplies, contracted services, vehicles, and necessary overhead.
15. *Literature cited* – List of all of the publications cited in the text of the proposal.
16. *List of potential reviewers* – Names (minimum of three) and addresses of research scientists with subject area expertise who could serve as peer reviewers for the proposal.

Proposal Review Process

The South Bay Salt Pond Project will award research grants that are selected competitively on the basis of technical merit and relevance of the proposed work to South Bay Salt Pond Restoration Project goals and objectives. To do this, the Science Program managers will institute an objective process for the anonymous peer evaluation of proposals that is efficient and achieves broadest acceptance of the process within the scientific and resource management communities. Peer-review panels will consist of experts external to the Project. The PMT will select the projects to be funded based on the results of the peer review and the Project priorities.

Peer Review. Peer-review panels should include enough technical experts to thoroughly evaluate all topical areas of the proposals. The panel members should be active estuarine, freshwater or watershed research scientists/engineers who have a high degree of stature, are well connected with other scientists in their respective fields, represent different specialties within these fields, and have some familiarity with the San Francisco Bay estuarine system. Science Program managers will ensure that panel members have no conflicts of interest (e.g., current or pending support from the Program). Reviewers will score the proposals, based on their scientific merit and the relevance to the call for proposals, with numerical ratings from 1 (Poor) to 5 (Excellent) using the following criteria:

- Technical merit including (a) research scope, justification, and importance of expected results; (b) reasonableness of the hypotheses and experimental design; (c) soundness of proposed steps for data collection, analysis and synthesis
- The appropriateness of the proposed study to the South Bay Salt Pond Restoration Project goals and objectives and responsiveness to the call for proposals.
- Qualifications of the investigators and adequacy of the facilities for carrying out the proposed research
- Reasonableness of costs
- Likelihood of success

In the case of continuing projects, consideration will also be given to the level of progress achieved to date.

When all reviews have been received, the proposals will be ranked by the peer-review panel. The panel will develop an overall prioritization of the proposals and will transmit its funding recommendations to the Science Program managers and the PMT.

PMT Review. The PMT will provide its review and approval of the new proposals to be funded based on the funding available for support of the proposals under each call for proposal. In its deliberations, the PMT, guided by the Science Program managers, will give most serious consideration to those proposals having been rated 4 or 5 by the Peer Review Panel, and will not select proposals rated 1 or 2. The PMT will also evaluate renewal proposals for continuation beyond the first year.

PART 2. DIRECTED STUDIES PROGRAM

In the course of developing the focused research questions, it will probably become apparent that a specific, sustained research effort may be necessary to resolve one or more of the areas of uncertainty regarding the important resources of the bay-delta-watershed critical to the Restoration Project's goals and objectives. Examples of such needs might include the following:

- Developing an understanding of a specific ecological phenomenon over long temporal and/or large spatial scales
- Conducting major synthetic and theoretical efforts
- Providing information for the identification and solution of specific salt pond management or restoration problems
- Quantifying the linkages between potential stressors and the abundance of species populations

Addressing such needs may require interdisciplinary research coordinated among investigators, experimental studies across a range of appropriate spatial and temporal scales, and development of analytical and numerical models of critical ecosystem functions and responses to management actions.

Given the scope and complexity of some of the issues facing the Restoration Project, it may be necessary to support such sustained commitments of effort irrespective of the responses of scientists/engineers to the annual requests for proposals. In such cases, the PMT may wish to contract with specific individuals or entities, because of recognized expertise, accomplishment, and past responsiveness, to carry out a program of directed research that is not well accommodated in the year-to-year call for proposals process.

Such questions, identified by the Science Program managers and PMT, will become the subject of contractual arrangements with specific individuals or entities. In each case, the individual/entity will develop a research proposal, using the call for proposals format described above, that will be subject to review and concurrence (or rejection) by the Science Program managers and other additional subject-matter referees as necessary, with revisions being made accordingly.

In recognition of the need in these instances for sustained study effort, funding will be provided to successful proponents for specified periods up to 5 years. It is expected, therefore that the Directed Research Program proposals will incorporate a detailed multi-year strategy and budget. It will also be understood that the Principal Investigator(s) will be expected to make a long-term commitment to meeting the critical South Bay Salt Pond Restoration Project research need(s) described in the contract.

The sustained research efforts under the Directed Research Program will be subject to frequent, vigorous peer review, i.e., at the proposal stage, during the conduct of the research, and upon the conclusion of the study. Written progress reports will be required at the end of each year, or sooner if needed, with a full review of project progress and accomplishment by the Science Review Board at least every three years. Contract renewals will be contingent upon the successful demonstration of progress toward meeting project goals and Restoration Project needs and the submittal of meritorious renewal proposals.

APPENDIX 5.
Descriptions of Phase 1 Applied Studies at Ponds E12/13 and A16/SF2

Experiments designed to address selected key uncertainties regarding bird use of managed ponds will be conducted as part of the Phase 1 actions. Specifically, these experiments address two key uncertainties: the extent to which managing ponds for target depths and salinities will increase pond use by waterbirds compared to existing ponds and the extent to which reconfiguring ponds to provide numerous nesting islands will increase the densities of nesting and foraging birds compared to existing ponds. The results of these experiments will inform adaptive management approaches to management of ponds throughout the SBSP Project area for selected bird species or groups of species.

Phase 1 Applied Studies at Ponds E12/E13

Key uncertainty: Will ponds reconfigured and managed to provide target water and salinity levels significantly increase the prey base for, and pond use by waterfowl, shorebirds and phalaropes/grebes compared to existing ponds not managed in this manner? Ponds managed as small-scale salt pond systems may provide enhanced benefits for wide range of birds. But, the extent to which they can improve the prey base and increase foraging shorebird densities in the short and long-term is not known.

Background/Rationale
Eden Landing Ponds E12 and E13 would be reconfigured to create shallow-water foraging habitat for migratory shorebirds, with a range of salinities, and a limited number of islands for nesting bird habitat (Figure 1). The restoration action would help maintain populations of bird species breeding at the salt ponds (project objective 1B.1) through the creation of nesting island and berm habitat; maintain habitat for salt pond-specialized birds (project objective 1B.2) by creating cells with elevated salinities; and maintain population levels of foraging shorebirds (projective objective 1B.3) by managing water levels and salinities to maximize foraging potential. These reconfigured ponds would test the extent to which focused management of shallow water habitats can increase migratory shorebird densities, the importance of salinity on the density of foraging shorebirds and their prey as applied studies, and techniques for vegetation management, predator management, and water and salinity management. The specific studies described below will address the following hypotheses:

- To what the extent will focused management of shallow-water habitats increase the densities of foraging shorebirds?
- What is the importance of salinity to the density of foraging shorebirds and their prey?

Applied Study Design Concepts
Several shorebird species, particularly Wilson's and Red-necked Phalaropes, have long been known to occur in the South Bay primarily within higher-salinity ponds. These species generally forage in high-salinity ponds throughout the tidal cycle. In addition, studies by PRBO and others have demonstrated that some species that typically forage on intertidal habitats during low tide, such as Western Sandpipers and Dunlin, show an affinity for higher-salinity (vs. lower-salinity) ponds at high tide, and that many individuals of these species forage in higher-salinity ponds at high tide. However, very high densities of shorebirds have also been observed foraging in South

Bay ponds that do not have high salinities, but do have optimal foraging depths for small shorebirds. The experiment at Ponds E12 and E13 would assess whether foraging shorebirds prefer low, moderate, or high salinity levels (and the associated prey types) in cells with similar shallow water depth habitat. The results of this experiment would determine the need for ponds with elevated salinity levels for foraging by migratory shorebirds in future phases of the project within the Adaptive Management Plan. Monitoring of the use of the constructed islands by nesting birds may provide some information regarding nesting bird use at the different salinity levels in the pond; however, this would not be the focus of the Ponds E12 and E13 applied study.

Study Methodology

Shorebird monitoring. Shorebirds in all cells would be monitored every other week from mid-July through April by observers walking or driving along the perimeter of the ponds (using spotting scopes). During each survey, the number of individuals of each species roosting and foraging in each cell during a two-hour period at high tide and a two-hour period at low tide (on the same day) would be recorded.

For an additional two hours during high tide, individual birds would be observed while foraging in an attempt to determine prey species. For a two-minute period, a single foraging individual would be watched. The foraging habitat, water depth, foraging method, and number of prey items taken by prey type (if determined) and foraging method would be recorded. If the bird spends time foraging in different habitat types (*e.g.*, mud vs. water) or using different methods, the proportion of the two-minute focal period spent using different habitats or methods would be recorded. After two minutes, a different bird would be observed, and so on, so that all the major species foraging in the ponds are represented by observations. Equal time observing foraging behavior would be spent in each of the three salinity treatments. The purpose of these observations would be to collect data that can be used to determine the optimal foraging conditions for birds within these ponds, and to attempt to relate foraging behavior and success to prey type and abundance (based on foraging habitat, water depth, foraging method, and in the case of larger prey items, observation of the prey items).

Prey monitoring. Invertebrates would be sampled at 10 locations within each salinity treatment during every other survey (*i.e.*, once/four weeks). Prey abundance would be estimated from these samples, including samples from both the water column and substrate, by prey type. Water depth, salinity, and temperature would be recorded at each sampling location.

Timeframe. The study would commence immediately following construction when water level management is underway. It is anticipated that a response to the reconfigured habitat will be discernable in the first season. However, meaningful results should be available after 5 years of monitoring.

Management Response

The extent to which salinity differences are found to affect shorebird species composition and density, foraging behavior of these birds, or the density and availability of important prey species will inform the future management of ponds within the SBSP Project area. If salinity differences significantly influence the use of managed ponds by waterbirds, future pond management in other areas may include salinity management to optimize densities of foraging birds. The results of this experiment, with respect to certain water salinities or depths corresponding to high densities of particular bird species, will also be used to optimize pond management for specific species or groups of species.

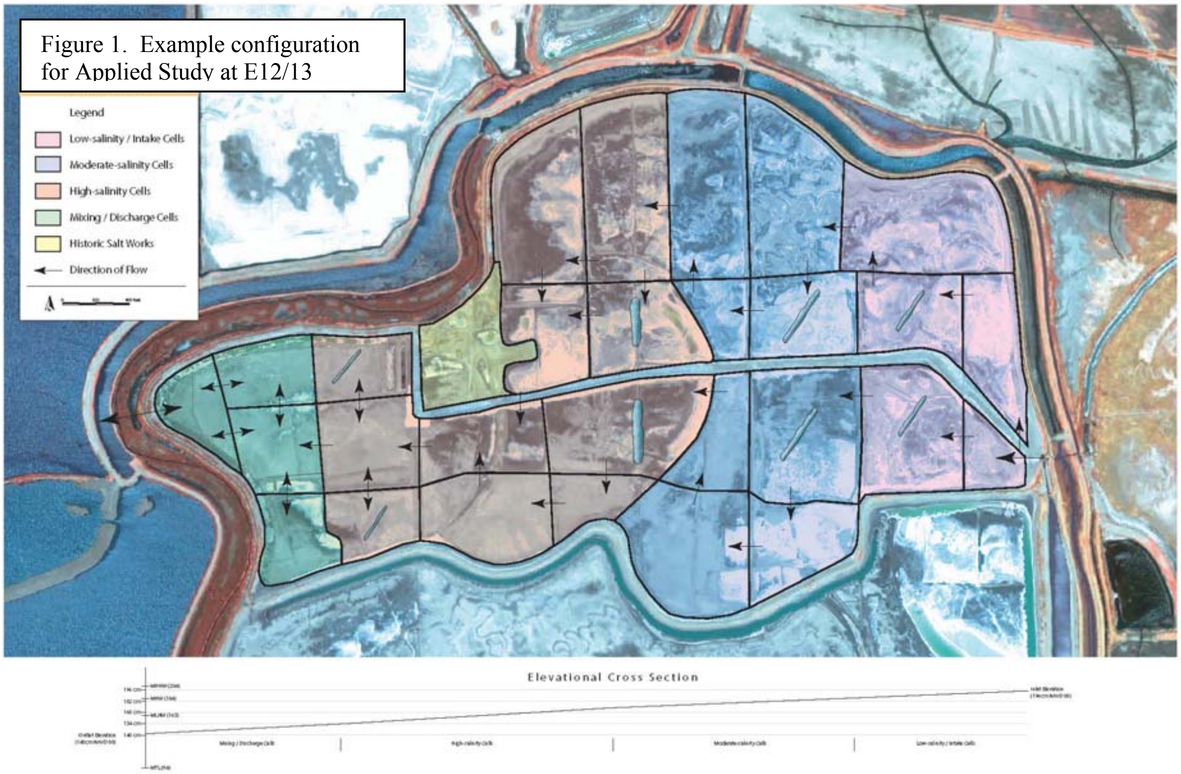


Figure 1. Example configuration for Applied Study at E12/13

Phase 1 Applied Studies at Ponds A16/SF2

Key uncertainty: Will ponds that are reconfigured to create large isolated islands for nesting and foraging significantly increase reproductive success for terns and other nesting birds and also increase the numbers and densities of foraging birds over the long term compared to existing ponds not managed in this manner? Constructing islands within managed ponds is expected to increase the densities of nesting birds in those ponds, and certain island shapes or densities may result in higher use by nesting birds than others. However, the extent to which nesting bird densities can be increased and sustained by island construction, and the shapes and densities of islands that will optimize bird use, is not known.

Background/Rationale

The A16 and SF2 managed ponds would be reconfigured to create islands for nesting birds and would be managed to provide shallow-water habitat for foraging waterbirds, particularly shorebirds (Figure 1). The Phase 1 actions at Ponds A16 and SF2 would help maintain populations of bird species breeding at the salt ponds (project objective 1B.1) through the creation of nesting islands and population levels of foraging shorebirds (projective objective 1B.3) by managing water levels to maximize foraging potential. These reconfigured ponds would test bird use of different island configurations as an applied study, and would also test management techniques for vegetation management, predator management, and water quality management. The specific studies described below will address the following hypotheses:

- Will pond reconfiguration to include numerous islands, and water-level management, increase the density of nesting and foraging shorebirds within Pond A16?
- Does island shape and density affect nesting success?
- Does vegetation type and density affect nesting success on the islands?
- Does passive human activity on trails affect nesting success on nearby islands?

Applied Study Design Concepts

Various nesting bird species may respond differently to different island shapes. For example, highly colonial species such as terns may make more use of circular islands while shorebirds such as Black-necked Stilts, American Avocets, and Snowy Plovers may benefit from long, linear islands. In addition to contrasting shapes, it is important to understand the effect of island density on habitat value. For example, high-density islands may reduce foraging area between islands and increase aggressive interactions among family groups of American Avocets and Black-necked Stilts. Vegetation also plays an important role in nesting success, as different birds species have varying vegetation tolerances or requirements. Snowy Plovers typically avoid vegetated areas for nesting, and avocets usually nest in bare or sparsely vegetated areas. While some South Bay tern colonies are located in areas with little or no vegetation, other tern colonies, as well as many Black-necked Stilt nests, are located in areas having some vegetation, which may also provide shade and cover from predators for chicks. Nesting waterfowl are likely to nest almost exclusively in vegetated areas. Although human activity in the vicinity of Ponds A16 and SF2 is expected to be limited to non-motorized recreation (*i.e.*, walking or biking around the outer levee of the pond) and pond/island maintenance, it is unknown whether this level of activity will affect island use or nesting success by birds.

The experimental studies designed for Ponds A16 and SF2 will provide an important model for island design, provide an understanding of the vegetation requirements of various pond-breeding bird species, and determine an acceptable level of human activity for reproductive success of bird species using managed ponds. This understanding will help inform and guide the design of optimal pond configurations that would be used at other locations in the South Bay.

Study Methodology

Island spacing, shape and distance to adjacent islands. Varying densities of islands will be created within Ponds A16 and SF2 to study the effects of island density on nesting bird use. There will be two island shapes: circular and linear (much longer than wide) to determine whether various nesting bird species respond differently to contrasting island shapes.

Vegetation type, density, and distribution. Vegetation is expected to establish on some of the islands after one or more years. At that point, the vegetation can either be controlled or vegetation can be manipulated by planting or selective removal, to determine the effects of vegetation type, density, and spatial distribution on nesting use and reproductive success of bird populations. The species composition, type of vegetation, and vegetation distribution will be manipulated by planting or selective control/removal to conduct studies to determine the effects and distribution of vegetation on nesting success. The decision regarding which plant species will be used in actual experiments will be determined by monitoring which vegetation types invade (and thus can be expected to survive on the islands) during the first few years following island construction.

Human activity. To determine whether human activities affect nesting birds at Ponds A16 and SF2, a portion of the trail around each pond (*e.g.*, along the entire northeastern side of Pond A16) could be closed during the breeding season every other year. The number of nests, and nest success and fledging success, would be estimated for a sample of islands to determine whether the location, number, and breeding success of birds varies depending on whether or not portions of the levee trails are open to human activity.

Timeframe. The study would commence prior to project implementation so that pre-construction conditions are documented. It is anticipated that a numerical response to island construction will be discernible in the first season after construction is complete and water level management is underway. However, it may be a few decades before ultimate densities are achieved as future phases of tidal restoration for the SBSP Project continue to reduce the amount of existing salt pond and levees available as potential nesting habitat.

Management Response

The extent to which the construction of nesting islands results in increased densities of nesting birds will inform the degree to which nesting islands are constructed in other managed ponds in the SBSP Project area. Species' responses to the shape and density of nesting islands will also help determine the types of islands that are constructed for nesting birds, and whether islands of various shapes or densities must be provided to optimize use by various species. The responses of nesting birds to vegetation type, density, and distribution will inform how the substrate on nesting islands should be managed for different species. If nesting birds respond negatively to increased human activity around the ponds, public access to trails will be modified (either spatially or temporally) to minimize disturbance. If no negative effects of human activity are noted, public access to trails will be incrementally increased and monitoring continued.

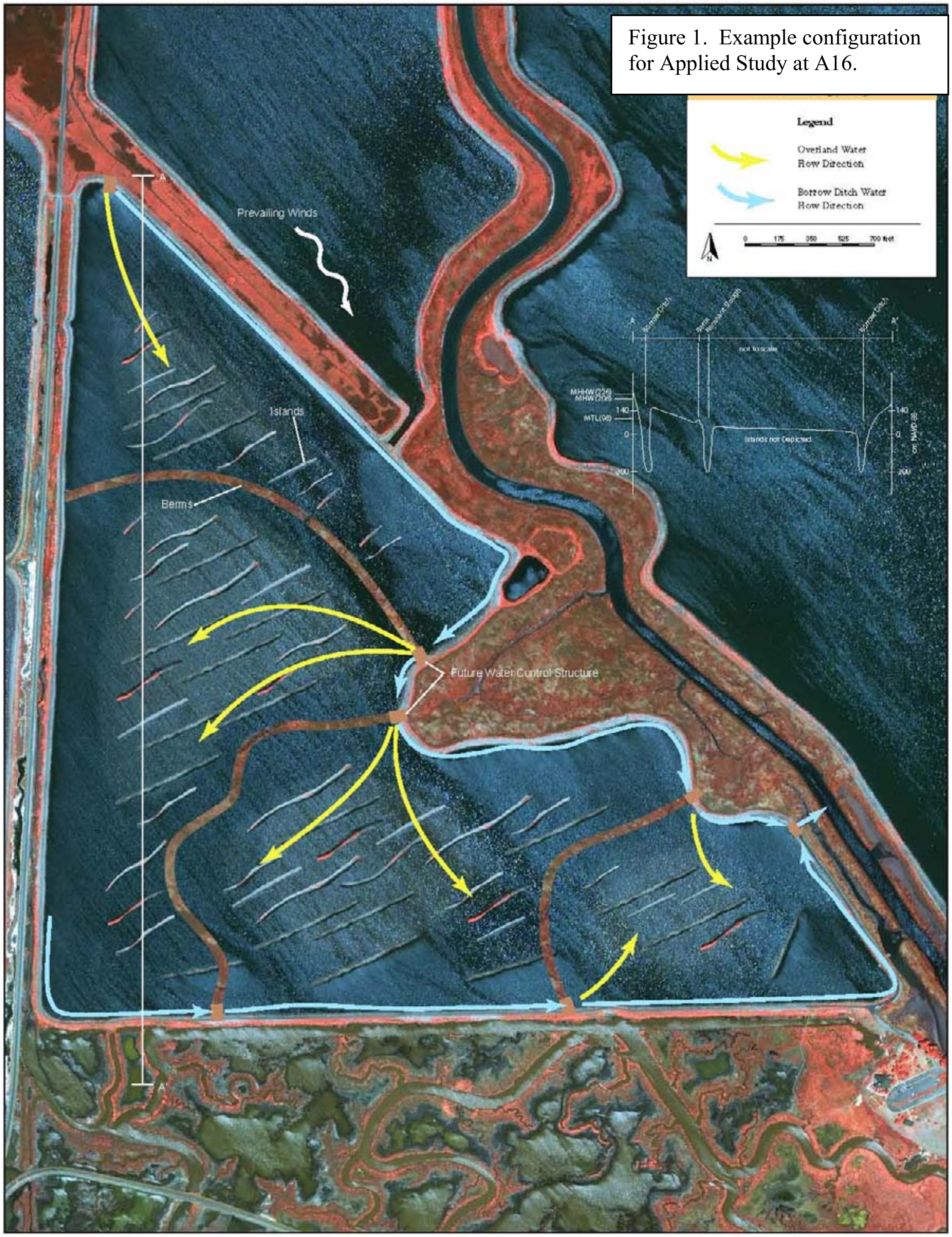


Figure 1. Example configuration for Applied Study at A16.

Addendum to the Adaptive Management Plan

2 March 2018

This Addendum to the Adaptive Management Plan (AMP) for the South Bay Salt Pond (SBSP) Restoration Project is intended to incorporate a new type of habitat restoration and enhancement feature to the previously adopted AMP. It defines and explains those features and sets for a system for how the AMP's principles and feedback mechanisms would be applied to the new features and what sorts of monitoring and adaptive management actions may be applied to them.

The SBSP Restoration Project is proposing the creation of habitat transition zones as part of Phase 2 actions. Habitat transition zones involve the beneficial reuse of material to create transitional habitats from the pond or marsh bottom to the adjacent upland habitat or levees along portions of the upland edge. These "habitat transition zones", are sometimes referred to elsewhere as "upland transition zones," "transition zone habitats," "ecotones," or "horizontal levees". Transition zones are specifically called out in documents such as the U.S. Fish and Wildlife Service's Tidal Marsh Recovery Plan and the recent Science Update to the Baylands Ecosystem Habitat Goals Project Report. A gradual transition from submerged Baylands, ponds, or open waters to uplands is largely missing in the current landscape of the South Bay, where there is often an abrupt boundary between the bay or ponds and the built environment. The SBSP Restoration Project's intention in including habitat transition zones in the Phase 2 alternatives is to restore this missing habitat feature. Doing so would:

1. Establish areas in which terrestrial marsh species can take refuge during high tides and storm events, thereby reducing their vulnerability.
2. Expand habitat for a variety of special status plant species that occupy this specific elevation zone.
3. Provide space for marshes to migrate upslope over time as sea-level rise occurs.

Before proposing these features, the SBSP Restoration Project examined the landscape to see if there are any areas adjacent to the project site where this could occur naturally. In general, the best locations for building these features would be located adjacent to open space or park land where the project can provide an even greater extent of transition into upland habitats.

However, at the edge of the Bay, these open space areas are largely former (now closed and capped) landfills which present a variety of challenges for creating the missing upland habitat. First, the existing elevation gradient between the restored marsh and the edge of the landfill is usually too steep to provide a gradual transition. Secondly, these landfills would otherwise pose a water quality risk from erosion if tidal action were introduced immediately adjacent to the protective clay liner or un-engineered rip rap slopes. In these instances, it is necessary that the project place material inside the former salt ponds to create the desired slope (15:1 to 30:1). At other locations, the actual elevations landward of the project sites are too low to create an uphill slope with the desired habitat functions. Therefore, once levees are raised or improved, such as at the All-American Canal levees, the only area remaining to build the transition zones is into the salt ponds. Finally, most of the adjacent property is not within the SBSP Restoration Project's ability to acquire, whether or not it has the desired elevation profile, because it is currently developed. In addition to being very expensive to acquire these areas, it would be infeasible to relocate all of the residences and businesses that have been built adjacent to the salt ponds. For these reasons, the project plans to use fill from upland excavation projects to create habitat transition zones inside the former salt ponds. The transition zones would provide habitat complexity and connectivity as marsh is restored. This would help improve habitat quality, particularly for endangered and threatened species, and improve resiliency of the shoreline over time as sea levels rise.

The SBSP Restoration Project notes in this Addendum that there are other new actions associated with the ongoing and more basic actions of maintaining the habitat transition zones that are more like routine maintenance of any part of the National Wildlife Refuge than they are adaptive in nature. Those activities would include the same kinds of actions performed under various regulatory permits, guidance documents, and other agreed-upon protocols. For example, commonplace Refuge practices like trash removal, fencing repairs, biological monitoring of bird populations, trail upkeep, removing invasive plant species and controlling or removing nuisance wildlife species, and other actions would proceed as normal and would therefore be implemented as needed on the habitat transition zones.

More broadly, the SBSP Restoration Project would continue to cooperate with the Santa Clara County, Alameda County, and San Mateo County Mosquito Abatement Districts to provide access by these districts to control mosquito populations. The Project would also work with the Invasive Spartina Project to remove or control populations of the non-native forms of that plant species. Similar coordination efforts to coordinate with adjacent or nearby city or county parks to control and manage use of the public access trails near transition zones by humans (and their pets, if/where allowed) would proceed as normal. None of these actions is what is typically meant by “adaptive management”.

Therefore, the table below is limited to the two more adaptive aspects of habitat transition zones: (1) the successful establishment and spread of elevationally-varying vegetation communities and habitat types, and (2) the transition zones’ ability to help maintain or improve existing levels of flood protection in the areas landward of where they are constructed. This effect is largely indirect, as habitat transition zones do not directly provide flood protection but do help protect existing levees or uplands from scour or wave run-up.

Proposed New Rows for Adaptive Management Plan Summary Table

Category / Project Objective	Restoration Target	Monitoring Parameter (Method)	Spatial Scale for Monitoring Results	Expected Time Frame for Decision-Making	Management Trigger	Applied Studies	Potential Management Action
Habitat Transition Zones Project Objective 1A. Create, restore, or enhance habitats of sufficient size, function, and appropriate structure to promote restoration of native special-status plants and animals that depend on South San Francisco Bay habitat for all or part of their life cycles.	The range and mosaic/composition of various vegetation communities and associated wildlife species habitat on the transition zones is at or on a trajectory resembling that of a natural (i.e., predevelopment) gradient between intertidal mudflats, low tidal marsh, high tidal marsh, and upland vegetation. This includes characteristics such as vegetation acreage and density per unit of transitional habitat, species composition, and other observable aspects of existing natural or successful marsh restoration sites in South San Francisco Bay.	- Monitoring of planted vegetation to evaluate success of establishment and spread - Acreages of each type of sub-, inter-, and -supratidal habitat (collected via remote imagery with limited ground-truthing) as a percent of the total restoration area; plant species composition, including abundance of nonnatives such as those listed elsewhere in the AMP (qualitative assessments for invasive species will occur annually, quadrant or transect sampling once habitat transition zone has 20% vegetation cover); being on habitat trajectory toward a reference marsh and other restoration sites - Habitat qualities of those different elevationally varying habitat rated as high, medium, or low based on suitability or potential usefulness to Ridgway's rail and salt marsh harvest mouse, determined every 2-3 years using aerial photos, ground-truthing, and/or other methods to evaluate these characteristics - Habitat mapping will take place every 5-8 years, beginning 5 years after the different sections of the constructed transition zone have established vegetation communities. Once 40% vegetation cover has been achieved, species composition (including native vs non-native) will be collected in a variety of zones (low marsh, high marsh, upland) on each transition zone.	Each of the proposed Phase 2 transition zones would be monitored. There are six in total. Two in Pond R4, two in Pond A8S, and one each in Pond A1 and Pond A2W.	- Establishment of different vegetation communities on the lower slopes of habitat transition zones depends on tidal flux, the depth of each pond (i.e., pond bottom elevations relative to tidal elevations). Yet natural vegetation colonization is anticipated to be detectable within 5 years (or less) of reaching appropriate elevations, while habitat development trajectory anticipated to be detectable within 15 years (and possibly less) of the onset of vegetation colonization. - In the areas where planting would take place (the higher portions of the zones), the successful establishment and spread of the planted vegetation is expected to be detectable in 5 years. - Invasive species establishment is expected to be detectable within the first year of its occurrence.	- Failure of habitat transition zones to develop native vegetation communities in elevations where those are expected to develop. - Vegetation deviates significantly (30–50%) from projected trajectory after colonization elevations are achieved. - Failure of the zones to hold or retain actively seeded or planted vegetation communities in elevations where that takes place. - Non-native Spartina, Pepperweed or Phragmites present in large numbers on site. - A level of invasive plant establishment and resistance to active control and management efforts that undermines the ecological values of the native communities and habitats intended for the transition zones to provide. - Inability to control and prevent outbreaks of vector (mosquitoes) on the slopes of the habitat transition zones using the methods and techniques discussed in the Vector Control Project Objectives.	**Applied Study Question #2017-1. Will habitat transition zones become established with naturalistic, native vegetation communities across a range of elevations and thereby provide a gradient of habitats for marsh plants and special-status species, including the California Ridgway's rail and the salt marsh harvest mouse?** Project Objective 1A states that the South Bay Salt Pond Restoration Project will create, restore, or enhance habitats of sufficient size, function, and appropriate structure to promote restoration of native special-status plants and animals that depend on South San Francisco Bay habitat for all or part of their life cycles. Most ecotone and transitional habitat between the waters of San Francisco Bay and the adjacent uplands have been lost as a consequence of historical land use and development. The Phase 2 actions to construct habitat features to replace this lost natural gradient is an important part of meeting Project Objective 1A.	- Study causes of slow vegetation establishment - Active revegetation - Increased non-native invasive plant species control - If invasive species cannot be controlled, study biotic response to non-native vegetation - Continue to re-evaluate what is meant by "control" of invasive species and adjust monitoring and management triggers based on the latest scientific consensus

Category / Project Objective	Restoration Target	Monitoring Parameter (Method)	Spatial Scale for Monitoring Results	Expected Time Frame for Decision-Making	Management Trigger	Applied Studies	Potential Management Action
Habitat Transition Zones. Project Objective 2. Maintain or improve existing levels of flood protection in the South Bay area.	- No increase in tidal flood risk at any levee or adjacent uplands associated with a habitat transition zone.	- Collect high water mark elevations on the existing levees and adjacent uplands prior to construction and then periodically after construction, especially following large storm or flood events. - Inspect for levee erosion initially monthly, then annually, and after major rainfall and/or tidal events	Each of the proposed Phase 2 transition zones would be monitored. There are six in total. Two in Pond R4, two in Pond A8S, and one each in Pond A1 and Pond A2W.	- Slope failure or erosion/scour is expected to be detectable within 5 years of normal weather, but heavy storm years may cause it to occur earlier or sooner. -If after 10 years, no substantial failure or erosion beyond minor, localized failures, it would be unlikely to occur, as the vegetation communities and natural sediment dynamics should have become established.	- Significant erosion observed - Elevated (higher) water surface elevations projected by modeling effort and/or observed in the field - Field data collection and/or observation indicates that flood risk is greater than that predicted by models	**Are habitat transition zones effective in slowing the amount of erosion or scour due to tides, storm surges, wind waves, or other erosional forces and thereby reducing the risk of levee failure or other aspects of flood risk to surrounding communities and infrastructure?** Habitat transition zones also address Project Objective 2 (Maintain or improve existing levels of flood protection in the South Bay area) because they slow wave run up, buffer storm surges, and provide a broader range of roughly horizontal surfaces on which sediment can accrete and vegetation can form. They thereby provide a foundation for naturalistic future sea-level rise adaptation by providing substrate on which tidally varying habitats can migrate upslope.	- Reconstruct failing portions of the habitat transition zones with material of higher quality. - Construct transition zones with a higher level of soil compaction.