South Bay Salt Pond Restoration Project

Science Strategy

A Framework for Guiding Scientific Input into the Restoration Process

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EXECUTIVE SUMMARY

The South Bay Salt Pond Restoration Project is in the first year of a five-year planning process for designing the restoration of over 6100 hectares (>15,000 acres) of salt ponds. The large-scale restoration of tidal wetlands habitat in the South San Francisco Bay represents a complex, highly technical undertaking that holds enormous promise for the future health of the Bay. Yet, as few habitat restorations have ever been undertaken on such a massive scale, the Project faces considerable uncertainties that may affect its' successful execution. In recognition of the critical role that well-grounded science must play in the implementation of the restoration, the National Science Panel recommended the establishment of an independent Science Team whose mandate is to ensure that the long-term restoration plan is based on the best available science and that independent scientific review occurs as an integral part of the project from beginning to end.

The "Science Strategy" represents the Science Team's plan and initial guidance for introducing solid science into the project at its inception. Closely tied to the Science Strategy are a series of linked Draft Conceptual Models designed to assist in restoration planning. The Strategy report provides an overview of the conceptual models that detail the various habitats being affected or restored. The ecological background to the Conceptual Models is found in Appendix A, and the models themselves are found in Appendix B. These models address the effects that restoration actions will have at both the landscape and pond-level scales. Eventually the models will be used to simulate and analyze potential restoration actions and outcomes. The Strategy report goes on to identify and prioritize key questions and data needs that are fundamental to meeting immediate project milestones. Because modeling will be such an integral part of restoration design planning, a discussion about choosing and using models in the planning phase is provided in Chapter 4. In Chapter 5, direction is given on the types of studies and monitoring that will be necessary to address critical questions identified at the beginning and throughout the project. Processes for Science Team guidance, peer review of plans and products, and information flow are described in Chapters 6 and 7. Finally, the recommendations in Chapters 5 and 6 for implementing a process to find the best academic and professional experts to study critical questions are expanded upon in Appendix C.

The Science Team strongly emphasizes that the ultimate long-term success of this restoration will depend upon efficient and timely use of applied studies, pilot projects, and adaptive management techniques throughout the restoration process. Applied studies and pilot projects can help reduce scientific uncertainty before phase 1 restoration actions are undertaken, and adaptive management will allow for the implementation of course corrections and improved techniques as they become identified through ongoing restoration monitoring. Adequate funding to support applied studies and monitoring will be crucial throughout the life of the project.

CHAPTER 1- INTRODUCTION TO THE SCIENCE STRATEGY

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1.1 Background

In March of 2003, state and federal agencies acquired from Cargill Company more than 6100 hectares (>15,000 acres) of solar evaporation salt ponds in South San Francisco Bay. 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 (Project), managed collaboratively by the California State Coastal Conservancy, the U.S. Fish and Wildlife Service, and the California Department of Fish and Game, has established goals that, when met, will provide for the restoration of diverse habitats for fish and wildlife species, particularly special status species, as well as providing wildlife-oriented recreation and education and maintaining flood protection.

Project participants - agencies, stakeholders, and the public - face substantial technical challenges as they undertake the process of designing and implementing a comprehensive and long-term restoration program for the vast network of solar evaporation ponds in South San Francisco Bay. As summarized on the South Bay Salt Pond Restoration Project website, http://www.southbayrestoration.org/Project_Description.html#Description:

> "The restoration and management of the South Bay Salt Ponds present scientific and technological challenges. Restoration will involve many complex issues – such as determining the desired mix of managed pond and tidal marsh habitat, the availability of sediment to create dikes and levees, designing flood management structures, protection of existing infrastructure (such as power lines), and controlling invasive plant and animal species. And the ecological and habitat goals must be balanced with human needs, such as opportunities to provide for wildlife oriented recreation."

To accomplish a successful restoration program that meets the above challenges, the Project is undertaking the following specific plan elements that are described on the project website:

1. Analyze Existing Conditions,
2. Develop Restoration Goals and Objectives,
3. Develop Strategy for Integrating Flood Management, Public Access and Habitat Restoration,
4. Develop Alternatives for Habitat Restoration,
5. Conduct Technical Analysis of Alternatives,
6. Conduct Environmental Review of Alternatives,
7. Select Preferred Alternative and Design Selected Alternative,
8. Develop a Monitoring, Maintenance, and Adaptive Management Plan
9. Acquire all Necessary Federal, State, and Local Permits, and
10. Complete Project Work to Ready Project for the Next Steps.

The first eight of these ten Project plan elements will require good science and sound methodological approaches, the development of a high level of understanding of the relevant ecosystem features and processes, and critical guidance and independent review of plans and recommendations as the Project proceeds. We view the accomplishment of each of these restoration plan elements as significant milestones in the restoration process, and we have developed guidance and plans to help the Project Management Team (PMT) achieve these milestones.

In recognition of the technical and scientific challenges facing such a large-scale restoration effort, the participants of the Project (Center for Collaborative Policy 2003) have established the following mandate as one of its Guiding Principles:

> ***"The Long-Term Restoration Plan is based on the best available science, and independent scientific review is an integral part of its development and implementation."***

Incorporating scientific understanding into all aspects of restoration planning requires that the Project have mechanisms to ensure that existing knowledge is critically evaluated and synthesized; that new studies of key issues, based on sound research plans, are carried out; and that all outcomes, including proposed plans, study results, actions, and all related written products stand the tests of appropriateness, thoroughness, reliability, and credibility. To achieve this, the Science Team, composed of local wetland and restoration experts, has been tasked by the National Science Panel (NSP) with developing a comprehensive Science Strategy and Conceptual Models, keystones in guiding science implementation. In addition to this work, the Science Team will develop other guidance documents as needed (for example, a companion document, "Decision Criteria for Selecting Ponds for Restoration or Management", to be drafted) and will provide peer review and scientific guidance.

1.2 Overview of the Science Strategy Elements

The Science Strategy for the Project is a framework for incorporating science into the planning process and for providing a "sound scientific basis for restoration decision-making at all stages of the process" (National Science Panel 2003). Specifically, the NSP established these six goals for the Science Strategy:

1. Establish a scientific framework and gather information that feeds into the restoration planning and execution process,
2. Be based on milestones in restoration planning and execution,
3. Identify science needs of each milestone and outline a process to meet those needs,
4. Outline processes for developing and refining conceptual models,
5. Outline processes for identifying and prioritizing major uncertainties, and
6. Outline processes for appropriate peer review.

This document describes how the Science Team will ensure that appropriate scientific guidance is provided to the Consultant Team, the Project Management Team, the public, and regulators at various stages in the long-term restoration planning and initial implementation process. The Science Team is not responsible for producing the specific restoration planning documents; this is the job of the consultants who will actually be doing the work. Rather, the Science Team will provide guidance to the consultants during the course of project planning and design, and will oversee the review of work products (Figure 1.1).

The chapters in this Science Strategy report address the six NSP goals as follows:

Chapter 2. Overview of Conceptual Models

A central task of the Science Team is to develop linked conceptual models addressing the effects of restoration actions at both the landscape and pond-level scales. The primary goals of these models are to provide overall scientific guidance, identify key processes that may require simulation modeling, identify uncertainties and data needs, and help educate the public about South Bay ecology and the restoration process. Chapter 2 gives key elements of the models as well as the process for developing and refining them (Goal 4). To provide context for the Conceptual Models, Appendix A briefly summarizes the basic physical, ecological and human processes that have shaped the South Bay of today. The draft models themselves are found in Appendix B.

Chapter 3. Key Questions and Data Needs

This chapter establishes a scientific framework based on key restoration and ecological questions that will help direct the gathering of essential information. Key questions and uncertainties are prioritized based on the data most needed to meet immediate Project milestones (Goals 1 and 5).

Chapter 4. Use of Models and Analytical Approaches

The conceptual models will eventually be developed into detailed, process-based simulation models to analyze potential restoration alternatives and outcomes. This chapter provides guidance on choosing and developing models and is designed to help in modeling alternatives, a key milestone in the planning process (Goals 1 and 2).

Chapter 5. Applied Studies and Monitoring

This chapter provides direction on the types of studies and monitoring necessary to address key questions identified initially and throughout restoration planning and initial implementation. In particular, this section discusses studies needed before restoration actions are implemented (2-5 year time frame), after the first projects are implemented (5-10 year time frame), and beyond (Goals 1, 2, and 3). Chapters 5 recommends instituting a program of grants, to be awarded on a competitive basis, to students, academics, scientists and engineers who could research critical scientific and technical issues (Goals 3, 5, and 6).

Chapter 6. Scientific Guidance and Peer Review

The Science Team is charged with providing scientific guidance and establishing peer review procedures. These tasks will be accomplished through application of routine technical guidance of Project plans and activities, as well as rigorous peer review of plans and products. The Science Team would also oversee aspects of the grant program for research.

Chapter 7. Schedule for Science Team Activities

Integrating science into the Project is essential, especially at critical planning milestones. This chapter provides a plan for how technical direction and scientific information will flow between the Science Team and the PMT, Consultant Team and the public (Goals 1 and 2).

1.3 Caveats about Science in the Restoration Process

While the incorporation of science into planning is designed to help the PMT produce the most successful project possible, science cannot answer all the ecological issues that will arise. It is important to acknowledge a few caveats about restoration:

- *Ecological Restoration is Experimental*. All restoration projects are experiments because we do not have a complete understanding of how ecological systems work. However, no matter how many studies we do, we will never know everything about restoring ecological systems. Rather, we must collect the data needed to move forward and then monitor the projects we undertake to learn which restoration actions work and which do not.
- *Uncertainty is Inherent in Restoration*. This caveat is closely related to the first one. Uncertainty exists in restoration because of our lack of data, but also because nature is variable and unpredictable, especially at long time scales. Once again, before we begin restoration, we must collect enough data to reduce basic uncertainties to the best we can, then we need to move forward by implementing projects, monitoring them and making improvements. We cannot, and should not control everything.
- *Potential Benefits and Costs*. Large-scale restoration, such is being planned in the South Bay, is likely to have effects that some people will perceive as negative. There are trade-offs or costs as well as benefits to nearly everything we do. For example, the planning for this project will incorporate recognition of the need for balancing the ecological benefits of tidal marsh restoration with the reduction of benefits that the salt ponds provide to some species. While there are likely to be a number of such trade-offs, the overall long-term benefits of this Project to the ecosystem are expected to substantially outweigh the costs to these species.
- *Change is Occurring and will Continue*. Whether salt pond restoration is undertaken or not, the ponds and the South Bay ecosystem are changing and will continue to do so. The challenge and promise of restoration is to direct change along a path that reverses damage caused by human activity and improves ecosystem integrity.

Figure 1.1. Application of Science Team Activities in the Technical Process.

This figure shows the general relationship between Science Team Activities (Science Strategy, Conceptual Models, and Other Science Team Guidance) and Consultant Products in determining the Phase 1 Restoration Projects to be undertaken in 2008.

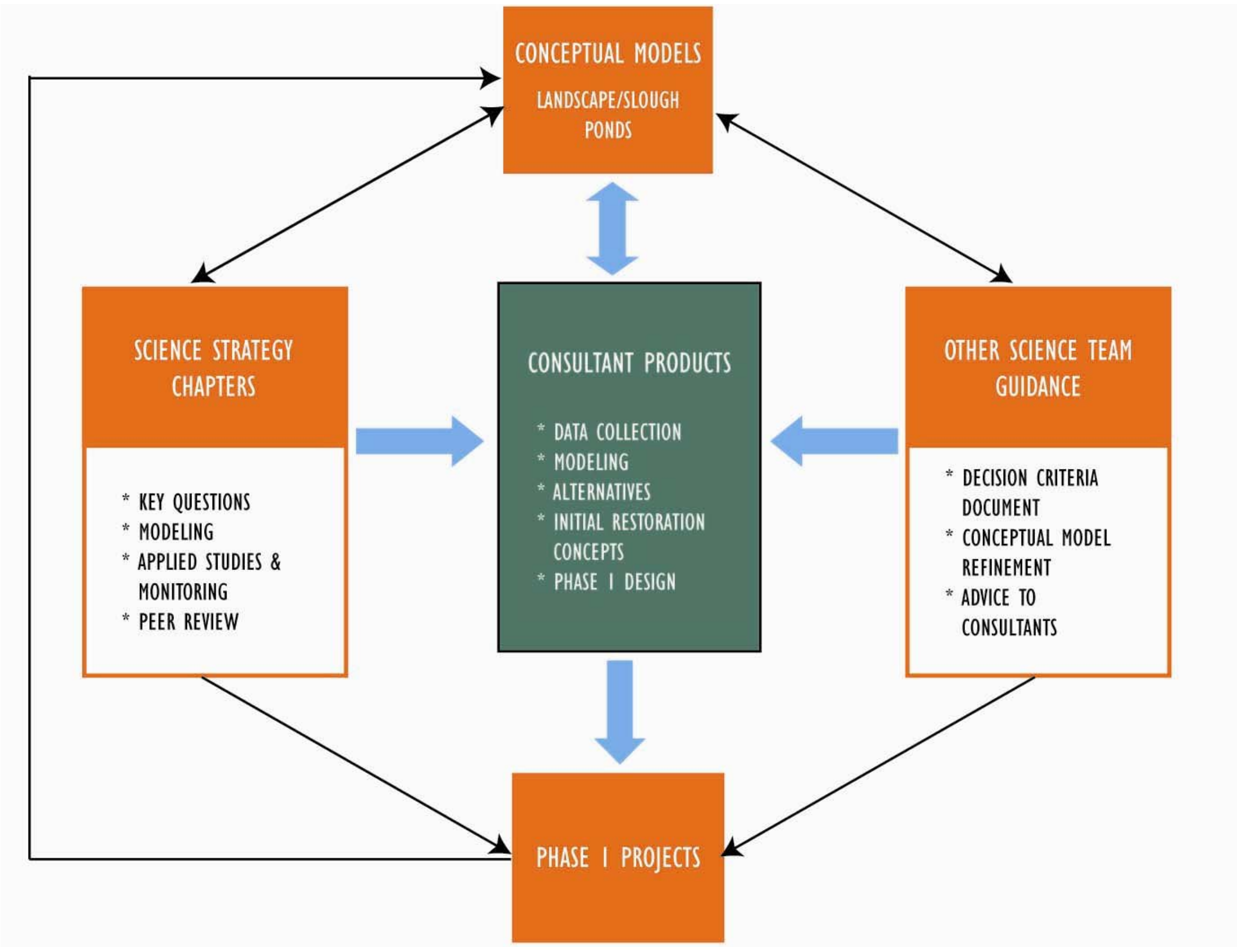

Figure 1.1. Application of Science Team Activities in the Technical Process

CHAPTER 2 - OVERVIEW OF THE CONCEPTUAL MODELS

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2.1 Purpose of the conceptual models

The Science Strategy begins with a discussion of the conceptual models, as they set the framework for planning the Project. The models (see Appendix B) focus restoration planning on the key processes and linkages affecting the development of South Bay ecosystems, including management actions that will affect these ecosystems. The specific objectives of the conceptual models are to:

- provide a comprehensive vision for the restoration of South Bay salt ponds.
- educate stakeholders and the public about the ecology of South Bay habitats and the processes and management actions needed to reach restoration goals.
- focus attention on key processes, habitat features and potential negative impacts of restoration efforts.
- articulate the expected ecological effects of salt pond restoration and management activities on South Bay ecosystems. This includes identifying the physical and biological driving forces that will affect ecosystem development, the constraints that may limit ecosystem development, and the opportunities for potential restoration and management actions.
- identify potential data gaps and uncertainties in our current understanding of restoration dynamics.
- identify evaluation criteria and other tools needed to compare the expected relative effectiveness of restoration alternatives in meeting Project goals.
- develop the approach for monitoring and adaptive management in order to reach specific quantifiable goals for the Project. This will include identifying metrics to evaluate and monitor restoration activities when the project is implemented.

Each conceptual model consists of text and flow charts. Ultimately, we will add graphics indicating physical processes and connectivity of different habitats. In addition, a parallel set of products will be produced that are understandable to the public. A central objective of the conceptual modeling effort is to provide information that will educate the public about the ecology of South Bay habitats and the processes and management actions needed to reach restoration goals.

2.2 Scale issues for the conceptual models

Appendix A briefly describes the Environmental Setting for this restoration effort. The size and scope of this Project is very large, and the effects of restoration and management activities will go beyond the ponds that are directly manipulated or managed. In evaluating the potential effects of restoration activities, it is important to consider the issue of spatial scale. Effects of restoration activities will vary along a continuum of spatial scales from specific ponds to the Pacific Flyway. However, effects will be most pronounced and measurable at scales from restored ponds to the entire South Bay. In order to incorporate this concept of spatial scale into restoration planning, we have developed a series of linked conceptual models along this continuum of spatial scale, with a landscape-level conceptual model (Appendix B.1) and a pair of local-level models that focus on individual ponds, tidal marsh model (Appendix B.2) and the managed pond model (Appendix B.3). All three models use the same model elements (Figure 2.1).

The Landscape Conceptual Model addresses the interactions of the restored ponds with both nearby sloughs and the larger South Bay ecosystem. At the slough level, interactions include hydrologic connections between adjacent ponds, dispersal of organisms among ponds, and other processes. At this level, questions may include: How will the restoration of landward ponds affect flow within adjacent sloughs? And, how will restoration affect sediment transport between landward and seaward ponds? At the South Bay scale, the model addresses questions such as: How might the restoration of multiple ponds affect nutrient and phytoplankton dynamics in the South Bay? How will large-scale pond restoration affect the cycling of contaminants in the South Bay? Or, how will large-scale pond restoration affect the stability of existing South Bay tidal flats? In addition, the landscape model also considers how landscape factors may affect restored ecosystems and target species.

At a smaller scale are the dynamics that will take place within a pond, whether it is restored to a tidal marsh with associated habitats or managed as a pond. Both pond-level conceptual models link natural processes and restoration actions, such as removing dikes or managing bay water flow, to show how desired habitats and conditions are likely to develop over time (See Figure 2.1). Both models consider how larger landscape processes will effect pond-level changes and, conversely, how pond restoration or management will impact current landscape conditions.

The Tidal Marsh Conceptual Model begins with initial pond and landscape conditions and describes how the implementation of restoration actions, such as breaching levees or importing dredged material, can lead to a range of desired tidal marsh and adjacent habitat types (See Table 2.1) depending on elevation, water and soil salinity, and species dispersal. For example, at high water and soil salinities, portions of a pond that become tidally-inundated due to levee breaches are likely to develop as a vegetated tidal salt marsh dominated by pickleweed (*Salicornia virginica*) and cordgrass (*Spartina foliosa*). At lower salinities, a pond newly opened to tidal fluctuation may become a brackish marsh, characterized by bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.). This model specifically addresses questions such as: How long will it take for elevations to reach appropriate levels for vegetation establishment within a particular pond? Will contaminants be mobilized within a pond following restoration activities?

The Managed Salt Pond Conceptual Model uses the same model elements as the Landscape and Tidal Marsh Conceptual Models to show how initial conditions in the ponds can be maintained or changed to benefit a range of species, especially those shorebird and waterfowl species now dependent on salt ponds of varying salinities and depths. For example, the installation of water flow structures, such as flap slidegates, can be used to alter the amount of bay water entering a pond. Relatively short residence times for water in a pond is conducive to typical South Bay fish such as topsmelt (*Atherinops affinis*) that are attractive prey to fish-eating birds such as terns (*Sterna* spp.). Longer residence time, resulting in high salinity water, will produce a pond that supports brine shrimp and brine flies, prey that attract a wide range of shorebird species. This model will answer questions such as: What will the effect of managing ponds of varying salinities be on South Bay water quality? To what extent can managed ponds support the current diversity of pond-dependent species at healthy population levels?

2.3 Possible restoration/management actions

The restoration Project will employ a number of restoration or management actions to initiate or alter the driving forces that will create or enhance habitat. The range of possible restoration and management actions includes, but may not be limited to the following:

- breaching or removing salt pond levees
- installing hydraulic infrastructure for managed ponds
- managing freshwater inflow into restored marshes
- managing inflow and outflow of ponds
- managing seasonal ponds
- filling restored ponds with dredge material or other fill materials, either partially or to desired marsh depths
- grading pond bottoms
- constructing or modifying habitat features, such as nesting islands, roosting habitats, pannes, and upland buffer areas
- creating channels in marsh plain
- maintaining, improving or modifying levees, including providing for flood protection and public access.
- dredging excess/toxic sediments
- planting/relocating key marsh species
- controlling *Spartina alterniflora* and other non-native plant species
- controlling non-native invertebrates and vertebrate species, such as Chinese mitten crabs, cats, and red fox.
- controlling artificial increases in gull and corvid populations

The conceptual models for tidal marsh and managed ponds include discussion of the restoration and management actions that are pertinent to the respective habitat goals. In addition, some of the restoration actions have the potential to affect conditions outside the ponds; these are discussed in the landscape-scale conceptual model.

2.4 Role of monitoring and adaptive management

By clearly identifying the desired ecosystem characteristics and functions that indicate the presence of desired habitats, the conceptual models will guide the development of a well-connected monitoring and adaptive management program. In addition, there will be feedback between monitoring activities and on-going conceptual model development. In linking the conceptual models and the monitoring program, it will be necessary to clearly identify specific goals and quantifiable parameters (metrics) for monitoring and evaluating restoration progress during the early planning phase. Parameters and target goals should address early and intermediate successional stages as well as the characteristics of the mature community.

Some data for setting quantitative targets exist in the literature. However, the scale of this restoration effort allows great opportunities to increase restoration knowledge through the incorporation of experimentation in the early phases of restoration. Restoration activities should be designed in a step-wise fashion, so that we can build on early experiments that provide insight into restoration design and ecosystem development.

2.5 Process for Developing and Refining the Conceptual Models

The models presented here are still very much in draft stage. They require more peer review and more attention to graphical presentation. It is the intention of the Science Team to continue developing the models over the next few months, in collaboration with the consultant team, to ensure that they accurately reflect both our understanding of the fundamental conditions and processes and the limits of our understanding. In addition, we expect that the models will continue to be refined throughout the planning process as we gain more knowledge about South Bay ecology and the effects of restoration actions. Thus, we consider the models described in Appendix B to be works in progress.

Table 2.1. Habitat types for the South Bay Salt Pond Restoration Project. Modified from Goals Project (1999).

<u>Bay</u>
Deep bay
Deep channel
Shallow bay
Shallow channel

<u>Baylands</u>
Tidal
- Tidal flat (also known as mudflat)
- Tidal marsh (including vegetated marsh, sloughs, ponds, pannes, and high marsh/upland transitional habitat)
  - Salt marsh
  - Brackish marsh
  - Tidal freshwater marsh

Diked / Non-Tidal
- Non-tidal freshwater marsh
- Managed (muted tidal) marsh
- Shallow saline pond
- Managed (muted tidal) pond

<u>Adjacent Habitats</u>
Riparian forest
Willow grove
Grasslands
- Perennial and annual grassland
- Moist-grassland
- Grassland/vernal pool complex

Coyote scrub

Figure 2.1. Elements of the Conceptual Models.

Each of the Conceptual Models uses these elements to illustrate the various effects restoration activities are expected to have on current conditions. Expected results include beneficial Desired Habitats and Target Conditions and Potential Impacts.

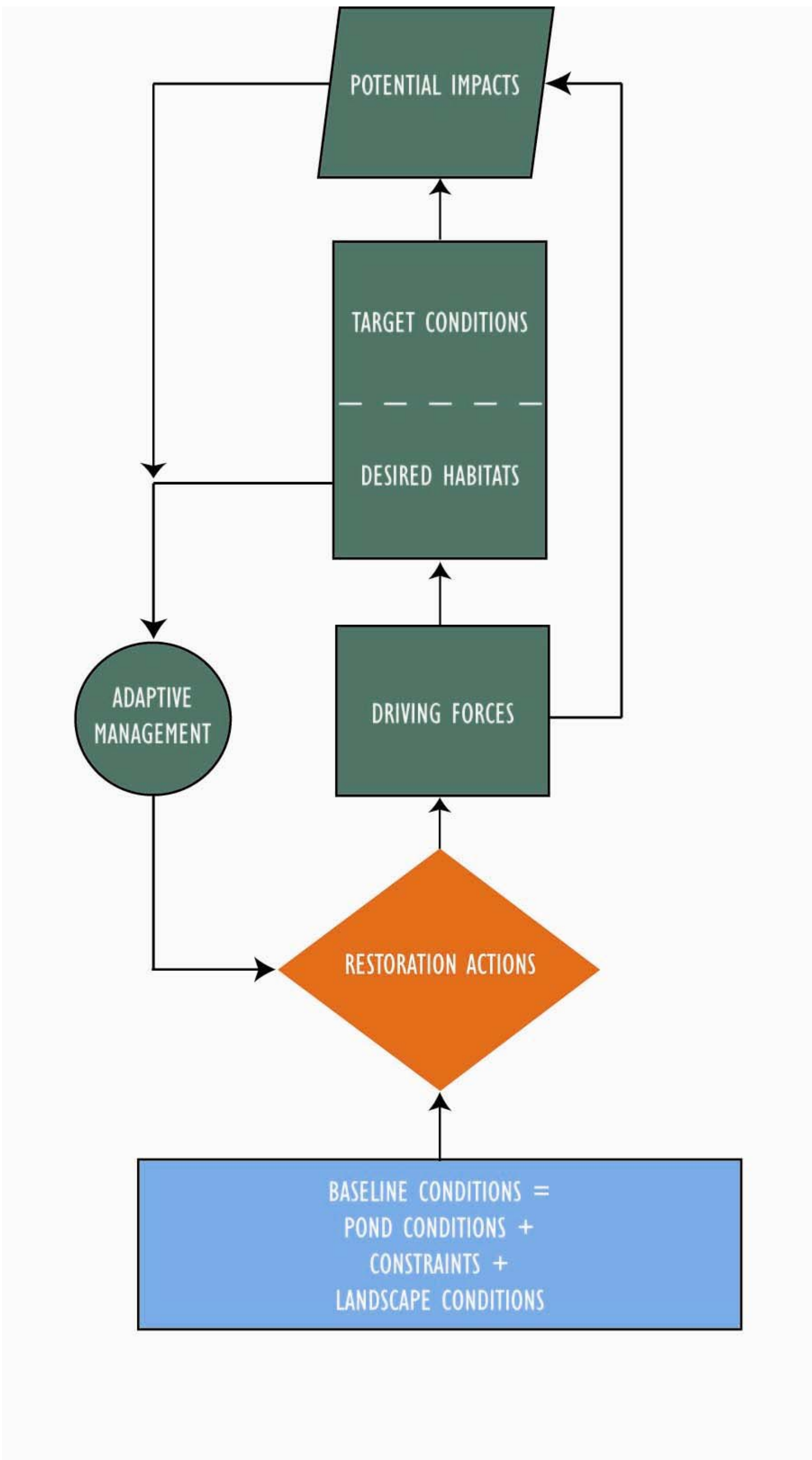

Figure 2.1. Elements of the Conceptual Models

CHAPTER 3 - KEY QUESTIONS AND DATA NEEDS

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3.1 Introduction

The conceptual models provide a comprehensive view of the South Bay system and insight into our knowledge gaps. This chapter outlines specific key considerations for salt pond restoration by compiling a list of the most important questions for the restoration effort. Multiple previous efforts have been made to collect and evaluate the specific needs and data gaps for wetland restoration in south San Francisco Bay, either specifically for the salt ponds (e.g., Siegel and Bachand 2002, Calif. Coastal Conservancy et al. 2003a, b) or in a broader sense (Goals Project 1999). We have made an effort to build on these previous, thorough efforts, and to distill the lists down to a shorter list of critical questions that are of the highest priority in the near term. Furthermore, our list focuses on science-based questions and does not directly consider policy or process issues.

The effort required to address the key questions ranges from compilation of existing data to development of long-term research programs. We have classified the key questions by type of approach and time scale, following the categories shown in Table 3.1. Careful monitoring of ongoing restoration will be the best method for some questions. For these questions, the early phases of restoration provide an opportunity to conduct experiments that will benefit future phases of the restoration. In order to adaptively manage the restoration effort, it is important to identify these topics early so that this type of experimentation can be incorporated and designed into the restoration process. While longer-term questions are of interest, the questions of highest priority for near-term project planning are those that can be answered in the short-term. Because of time constraints, some questions will have to be evaluated for near-term planning based on current knowledge, assumptions, and estimates. However, as additional data and insights become available in the future, it is expected that these questions will be reconsidered in more detail.

Table 3.1. Types of questions to consider for salt pond restoration.

Approach

A.1	questions that will require a synthesis of existing data and previous project experience (no new data collection needed).
A.2	questions that will require one-time or short-term collection of baseline data.
A.3	questions that will require collection of longer-term monitoring data.
A.4	questions that will require new applied studies and research, including experimentation.
A.5	questions that require numerical modeling.

Time scale

T.0	questions that need immediate answers.
T.1	questions that can be answered in the short term (next year or two).
T.2	questions that can be answered in the medium term (within three to five years).
T.3	questions that can be answered only with longer-term monitoring or research.

Below are questions grouped in four major topics: sediments, pollutants, non-native species, and habitat distribution. While flooding and public access issues are not indicated as major topics, we have included these issues under habitat distribution.

3.2 Sediments

Bed level in many of the salt ponds is significantly lower than required for functioning tidal marsh primarily because of subsidence. The entire South Bay region subsided during the second half of the 20th century due to excessive pumping of groundwater. Sediment deposition has largely compensated for subsidence in the South Bay outside the ponds, but the levees have kept Bay sediments out of the salt ponds. Today, the pond beds are lower than the floor of the adjacent baylands. As a result, a substantial quantity of sediment will be required for the restoration of the salt ponds to tidal marsh (Siegel and Bachand 2002). There are two options for the source of sediment; deposition driven by natural processes, or filling. Filling or partial filling would be faster but much more expensive, and is limited by the available volume of dredged material or other sources of fill. Once the levees are breached, sediment will be transported into the ponds by tidal transport and deposited there due to the low velocities within the ponds. The rate of accretion is difficult to predict. The source of the sediment could be new sediment coming into the system from nearby creeks or from the northern estuary, or redistribution within the South Bay, the latter of which could result in erosion of South Bay mudflats. For a full description of these alternatives and initial approximations of the time required to attain marsh-plain elevation, see the discussion in Siegel and Bachand (2002).

Finding the answers to two overarching questions related to sediment supply, sediment transport, and physical processes will be key to restoration planning irrespective of whatever combination of natural processes and filling with dredged sediments is employed:

I. Based on the sediment budget and sediment dynamics of the South Bay, what rates of net accretion can we expect in the breached ponds? For each alternative, is the anticipated rate of net accretion sufficient for the restoration effort to succeed in a reasonable timeframe?

II. How will the Project influence circulation, sediment transport, and morphology within and outside the Project area?

These two questions are clearly interrelated. In general, the need for a greater sediment supply to build and maintain habitat in the breached ponds, in a region that is not subject to large sediment inputs from the adjacent watersheds other than during brief winter floods, implies a greater sediment loss from the surrounding region. For this reason the questions related to sediment transport cannot (and should not) be cleanly divided between internal and external processes.

The following list of key questions starts with topics internal to the ponds and progresses to potential impacts outside the ponds. Suspended sediment concentrations and sediment transport are characterized by large spatial and temporal variability, and large uncertainties in measurement and prediction. Therefore, identifying uncertainties and ranges of response is an integral part of all questions. In this section and the ones that follow in this chapter, the likely approach and timeline (see Table 3.1) are listed in parenthesis after the question.

1. How much sediment is needed for each restoration alternative? Elements include a. existing bathymetry of ponds (ongoing USGS study) (short-term synthesis & baseline data), b. projected sea-level rise over the life of the Project (short-term synthesis), c. projected subsidence (short-term synthesis), d. contribution of organic material generated within the ponds. (projected contribution: short-term synthesis; actual contribution: long-term monitoring)
2. At what rate will sediment become available to the restored ponds? (all approaches, all timescales)
3. What are appropriate assumptions to use in predicting future sediment budgets: e.g., rate of subsidence; eustatic sea-level rise; suspended sediment concentrations? (short-term synthesis)
4. What is the rate of sediment input from local watersheds? (short-term synthesis & medium-term monitoring)
5. What is the rate of sediment input from the northern estuary? How does input vary in time? What is the relative importance of episodic and seasonal variability in loading from the northern estuary? (long-term research & applied studies)
6. What is the rate of sediment export from South Bay, and how does it vary in time? (medium-term monitoring)
7. What is the temporal variability in suspended sediment concentrations in South Bay? In the channels? Over the mudflats? What is the role of wind, tides, or other factors in controlling these concentrations? (ongoing topic of investigation by D. Schoellhamer and colleagues, USGS) (short-term synthesis & medium-term research & applied studies & modeling)
8. What mechanisms control sediment transport between the channels and the shoals? (medium-term research)
9. What are the current and historical rates of sediment accretion in South Bay marshes (including natural and recently restored marshes) and adjacent mudflats? (short-term synthesis & medium-term monitoring)
10. Can the rapid filling that has occurred at some sites opened to tidal action in South Bay (for example, Charleston Slough) be accounted for based on ambient conditions? (short-term modeling)
11. Under existing conditions, how does the bathymetry of South Bay mudflats vary over decades, seasons, and in response to storm events? (Decadal change currently under investigation by B. Jaffe, USGS.) (decades: short-term synthesis; storm events: medium-term research)
12. How will the new sink created by opening up ponds to the tides alter the cycling of sediment in South Bay? (medium-term modeling; long-term monitoring & research)
13. What proportion of the source of sediments going to breached ponds will be material that would otherwise be exported from the South Bay out the Bay Bridge, and what proportion will be internal redistribution (primarily mudflats)? (short- & medium-term modeling)
14. How will the sediment budget evolve over time after the pond levees are breached? (medium-term modeling & long-term monitoring)

15. Will changes in sediment cycling caused by the Project alter a) the amount of tidal flats available for birds and other animals, and b) the resource value of tidal flats for migratory birds? (medium- and long-term modeling, monitoring & applied studies)
16. How will pond levee breaches affect tidal currents and circulation patterns in the sloughs and South Bay and how will these effects change in time as the pond bed elevation and breach geometry approach equilibrium conditions? (short-term modeling & long-term monitoring and applied studies)
17. To what extent will alteration of tidal currents cause erosion of sloughs, channels or mudflats, and alter sediment transport patterns? (short-term modeling & long-term monitoring)
18. How will the pond levee breaches alter circulation and residence times, particularly south of the Dumbarton Bridge (the region most impacted by the discharge of treated wastewater)? (short-term modeling)
19. How can experimentation and pilot projects be used to address sediment questions?

3.3 Water Quality and Pollutants

Many salt ponds in the South Bay, after decades of salt production by solar evaporation of sea water, contain high concentrations of various sea salts, including gypsum ($CaSO_4 \cdot 2H_2O$) in high salinity ponds. These salts will have to be diluted or otherwise physically removed from the ponds before habitat restoration can occur. At the same time, a number of contaminants are found in pond sediments, including PCBs, DDT, PBDE, Chlordanes, and mercury. Interestingly, these contaminants are generally found in concentrations lower than that in the sediments of the surrounding marshes and creeks (Siegel and Bachand 2002). The implication of this finding is that restoration of South Bay salt ponds to tidal action will probably lead to an increase in some or all of these contaminants in the sediments of newly created habitats, particularly mercury (Davis et al. 2003). In addition, restoration to salt marsh may increase the bioavailability of these contaminants (Gill et al. 2002). There is increasing evidence, for example, that biological and sedimentological conditions in newly created wetlands can stimulate the methylation of mercury. Further, a substantial reduction of salinity levels below salt production levels in those ponds that will continue to be operated as managed ponds may result in nuisance algal blooms and the production of hydrogen sulfide without proper management (Siegel and Bachand 2002).

While many questions concerning the contaminant issues have already been articulated (Calif. Coastal Conservancy et al. 2003a, b), several key questions need to be addressed before restoration can proceed. These include the following:

1. What are the present distributions of contaminants in the sediments of each of the existing ponds, in the adjacent marshes, and in tidal channels? (short-term synthesis & baseline data)
2. What are the major sources of “new” contamination, particularly that of mercury? (short-term synthesis)
3. What are the mechanisms involved in the transport of specific “new” contaminants from their principal sources, including nearby waste water treatment plants, to the salt pond region of South Bay? (short-term synthesis)

4. What historically-deposited contaminants might become biologically available if mudflats and slough channels (particularly Alviso Slough) scour following the opening of ponds to tides? (short-term synthesis & baseline data)
5. What are the mechanisms involved in the movement (erosion, transport, and deposition) of "old" contaminants already present in sediments in the vicinity of the salt ponds? (short-term synthesis)
6. Are there design alternatives, e.g., breach location and design, that can be incorporated to dampen the influx of "new" contaminants from distant sources such as the Guadalupe River watershed? (medium-term synthesis)
7. Are there design alternatives, e.g., breach location and design and use of external sources of sediments to raise pond elevations prior to restoration, that can be implemented to reduce erosion of channel banks and outboard mudflats, thereby limiting the mobilization of previously deposited "old" contaminants? (medium-term synthesis)
8. What are the physical and chemical conditions in newly created wetlands that can exacerbate or lessen the rate of mercury methylation? (short-term synthesis)
9. What are the linkages between habitat type, contaminant cycling and the foraging behavior of species of concern? (medium-term monitoring)
10. Will the rates of mercury methylation within newly created wetlands reach levels that are harmful to species of concern? (long-term monitoring)
11. What is the current potential for Hg-methylation along the salinity gradient of the existing ponds compared to non-enclosed South Bay open water and marsh areas?
12. What is the potential for nuisance algal blooms in future managed ponds? (medium-term monitoring)
13. What steps can be taken to control algal blooms in these ponds? (medium-term synthesis)
14. How might biological oxygen demand (BOD) in managed ponds effluent affect dissolved oxygen (DO) in the channels?
15. How will the Project alter nutrient cycling and primary production in South Bay? (long-term monitoring)
16. What is the potential threat of avian botulism and/ or cholera occurring in managed ponds?
17. How can experimentation or pilot projects be used to address methyl mercury questions?

3.4 Non-Native Species

Non-native species have caused significant impacts within San Francisco Bay (Cohen and Carlton 1998), resulting in shifts in food webs, impacts on native species and other ecosystem-level changes (Nichols et al. 1990, Alpine and Cloern 1992). Within vegetated wetlands in the Bay, one of the most problematic species is *Spartina alterniflora* (Callaway and Josselyn 1992), as well as the hybrid of *S. alterniflora* and the native *Spartina foliosa* (Daehler and Strong 1997). *Spartina alterniflora* can shift mudflat distributions, change creek geomorphology, and affect habitat conditions. Given the large existing populations of *S. alterniflora* and the hybrid in South Bay, there are numerous concerns about potential effects and further spread due to salt pond restoration. An EIS/EIR for a control program was recently completed (see web page for the San Francisco Estuary Invasive *Spartina* Project for more details: www.spartina.org); however, it is not likely that the non-native *Spartina* species will be eradicated completely from the Bay before salt pond restoration is initiated. Focus will remain on options for short-term containment of *S. alterniflora* and the hybrid, as well as the longer-term possibility of eradicating this species.

In addition to *Spartina*, other problematic non-native species are those that have a significant effect on ecosystem processes (e.g., changing food web patterns or habitat development). This includes predators such as red fox, dogs, and cats, as well as other organisms, including invertebrates, which may affect marsh stability through burrowing, or affect food webs. Key questions to consider for non-native species include:

1. To what extent can *Spartina alterniflora* and the hybrid be controlled prior to restoration? (medium-term synthesis & research)
2. What are the specific ecosystem-level effects of non-native *Spartina* species that would most likely affect the success of newly created wetlands? (predicted effects: short-term synthesis; actual effects: long-term monitoring and research)
3. What is the likelihood of establishment for non-native *Spartina* species given different scenarios of control and restoration design and timing? (medium-term research)
4. On what spatial scale does control need to take place in order to reduce the likelihood of *Spartina alterniflora* establishment within a restored pond? (medium-term research)
5. Are there design alternatives, e.g., breach location and design, that can be incorporated to dampen the influx of *Spartina* propagules into newly restored wetlands? (medium-term synthesis & research)
6. What other non-native species (plants and animals), including *Lepidium latifolium*, *Salsola soda,* and the Chinese Mitten Crab, currently are found in the South Bay and may be problematic for restoration? (short-term synthesis)
7. Will restoration increase populations of corvids (a native species but with effects that are similar to many non-native predators), and what will their impact be on native bird species, especially breeding species (e.g., Snowy Plovers)? (medium-term synthesis & monitoring)
8. What ecosystem-level effects are likely from these particular non-native species? (long-term synthesis & monitoring)
9. What non-native species in San Francisco Bay are unlikely to be controlled with or without restoration? (medium-term synthesis)
10. What current level of predation and/or disturbance is occurring due to non-native predators such as fox, cats, and dogs, and how do they gain access to existing wetland habitats? (short-term baseline data and medium-term research)
11. Are there design alternatives, e.g., levee design, breach location, etc., that can be incorporated to prevent the access of non-native terrestrial predators into restored wetlands? (medium-term synthesis & research)
12. How can experimentation or pilot projects be used to address non-native species questions? (short-term synthesis)

3.5 Habitat Distribution and Quality

Determining the desired distribution of different habitat types within the restored area is a significant planning decision for the restoration effort. While this decision will rely primarily on policy concerns, sediment availability, and cost, there are also important scientific questions concerning habitat distributions.

1. What are the ecosystem functions (e.g., hydrologic functions, food-web support, habitat support, etc.) that are provided by the various habitat types, including existing habitats (i.e., salt ponds) and habitats that are planned for future restoration? (short-term synthesis)
2. What are the habitat needs of target species of interest, and conversely, what species are supported by the various habitat types? (short-term synthesis & baseline data)
3. How will the conversion of salt ponds to other habitat types affect bird populations that currently use salt pond habitats (Western Sandpipers, Dunlin, Canvasbacks, Scaup, etc.)? (short-term synthesis & medium-term monitoring)
4. What physical factors drive the conversion of one habitat type to another? (medium-term synthesis & monitoring)
5. Are there any critical factors that may limit ecosystem development (either completely restricting development or just slowing it down)? (medium-term synthesis & monitoring)
6. How do landscape-scale factors such as the spatial arrangement of habitats and their size affect overall ecosystem functions (e.g., do we know the minimum patch size of particular habitat types that will support species of interest, how does the mix and connectivity of habitat types affect use, do land-scale scale factors affect contaminant cycling dynamics)? (medium-term synthesis & monitoring; long-term research)
7. How will the surrounding landscape and land use affect habitat quality and response of the biota to restoration? (medium-term synthesis & monitoring)
8. What are the benefits of transitional upland habitats, and how can these transitional uplands be restored, especially considering adjacent development? (short-term synthesis; long-term monitoring & research)
9. How do rates of methyl-mercury production and degradation vary by habitat type (shorter-term synthesis; medium-term monitoring & research?
10. How will flood control influence habitat distribution planning decisions? (medium-term synthesis)
11. How will utility infrastructure influence habitat distribution planning decisions? (e.g., how do boardwalks through the marshes affect the distribution and access of predators into the marsh?) (medium-term synthesis)
12. How will public access constraints influence habitat distribution planning decisions? (medium-term synthesis; medium-term research)
13. How can experimentation or pilot projects be used to address habitat questions? (short-term synthesis)

3.6 Summary and Questions in Need of Immediate Action

In an attempt to prioritize the science needs for the Project, we have identified questions that are in need of immediate action and would provide the most benefit to restoration planning (Table 3.2). These priority questions need to be addressed in order to meet Project milestones (see Chapter 1). Given the scope of the Project, there are more scientific questions than can be addressed within the Project timeline and budget. Although the relative importance of these questions can be difficult to assess, it is essential to begin the process of prioritization in order to focus resources in the planning process. We expect the prioritization of key questions and data needs to be an iterative process, requiring on-going consultation between the Science Team, the PMT, Consultant Team and other participants in the Project (see Chapter 7). As identified above, key questions may be addressed through compilation of existing data, numerical modeling, or monitoring of existing restoration projects, reference sites, and pilot projects (also see Chapter 5). In addition, new research will be needed, and this should be initiated through the research grant process outlined in Chapter 5 and Appendix C.

Table 3.2. Immediate questions for salt pond restoration.

Sediments

- Based on current knowledge of the sediment budget and sediment dynamics of South Bay, what rate of elevational change will occur in the breached ponds and how does this relate to the initial conditions within each pond?
- What are appropriate assumptions to use in predicting future sediment budgets: e.g., rate of subsidence; eustatic sea-level rise; suspended sediment concentrations?
- To what extent will alteration of tidal currents due to levee breaches cause erosion of sloughs, channels or mudflats and how will this affect use by animals and plants?
- How will opening up ponds to tidal action affect the sediment budget and bathymetry, and how will this effect change over time?
- Under existing conditions, how does the bathymetry of South Bay mudflats vary over decades, seasons, and in response to storm events?

Water quality and pollutants

- What are the present distributions of contaminants in the sediments of each of the existing ponds, in the adjacent marshes, and in tidal channels?
- What are the major sources of "new" contamination, particularly that of mercury?
- What historically-deposited contaminants might become biologically available if mudflats and slough channels scour following the opening of ponds to tides?
- What are the physical and chemical conditions in newly created wetlands that can exacerbate or lessen the rate of mercury methylation?
- What are the current rates of Hg-methylation along the salinity gradient of the existing ponds compared to non-enclosed South Bay open water and marsh areas?
- How will salinity reduction during the Interim Stewardship Plan (ISP) alter animal and plant populations prior to initial restoration phases?
- How will the food webs within the breached ponds be affected by changes in salinity, and what impacts on birds might result?
- What is the potential for the occurrence of avian botulism in the managed ponds?

Non-native species

- To what extent can *Spartina alterniflora* and the hybrid be controlled prior to restoration?
- What are the specific ecosystem-level effects of non-native *Spartina* species that would most likely affect the success of newly created wetlands?

- What is the likelihood of establishment for non-native *Spartina* species given different scenarios of control and restoration design and timing?
- What other non-native species currently are found in the South Bay and may be problematic for restoration?
- What current level of predation and/or disturbance is occurring due to non-native predators such as fox, cats, and dogs, and how do they gain access to existing wetland habitats?

Habitat distribution and quality

- What are the ecosystem functions that are provided by the various habitat types, including existing habitats and habitats that are planned for future restoration?
- What are the habitat needs of target species of interest, and conversely, what species are supported by the various habitat types?
- Are there any critical factors that may limit ecosystem development?
- How will flood control influence habitat distribution planning decisions?
- How can experimentation or pilot projects be used to address habitat questions?
- How do rates of methyl-mercury production and degradation vary by habitat type?

CHAPTER 4 - USE OF MODELS AND ANALYTICAL METHODS

Chapter 4. USE OF MODELS AND ANALYTICAL APPROACHES

The planning of the South Bay Salt Pond Restoration Project (Project) will require detailed technical study including application of numerical models. We believe that an early and full discussion of the proposed modeling and analytical approaches will help focus the planning effort and reduce the number and severity of critical review comments later in the process. The Science Team can provide input to the technical studies in several distinct ways and should be involved in review throughout the process of model development and alternatives analysis.

In the following text we describe how the Science Team and the Consultant Team should work together to reach agreement on a technical approach that is appropriate. We offer a number of recommendations herein with the understanding that many decisions regarding the technical approach will be made by the Consultant Team. The Consultant Team will communicate frequently with the Science Team, and provide written information, perhaps on a bi-monthly basis, that the Science Team can review. The purpose of regular communication and the review of bi-monthly progress is to ensure agreement on fundamental issues as the project evolves.

In this chapter we make several general recommendations related to hydrodynamic, water quality and ecological modeling. They are intended to supplement the more specific recommendations on hydrodynamic modeling approaches have been made previously in Hydrodynamic Modeling Tools and Techniques (Moffatt and Nichol 2003b). We recommend that the Consultant Team review the Hydrodynamic Modeling Tools and Techniques document and consider the recommendations therein prior to proposing a technical approach for each phase of the technical study.

4.1 Use of Conceptual Model in Technical Studies

The draft conceptual models developed by the Science Team, in collaboration with the Consultant Team, will guide the scope, implementation, and interpretation of the technical analyses performed in the Project planning process. The conceptual models are expected to be a dynamic tool that will evolve during the technical study, partially in response to the conclusions of the technical studies. Therefore, it is expected that the Consultant Team will suggest revisions and provide additional detail as the planning work proceeds.

The conceptual models will include components at two spatial scales: pond and landscape. The pond component will consist of a set of submodels for different habitat types. The draft conceptual models should provide useful guidance in the technical studies, but they are not highly detailed. The models in conjunction with the Key Questions (Chapter 3) will help give direction on modeling needed. We suggest that the Consultant Team further develop the conceptual model into a series of process-based models that indicate all processes that will be considered in the technical analyses. These process-based models would supplement the draft conceptual models and assist the Science Team, Project Management Team (PMT), and others involved in the planning study, to understand the scope and level of detail of the planning studies. We suggest that the models be prepared both with the full level of detail appropriate for review by the Science Team and in a more simplified form intended for the general public.

The conceptual models also include a set of definitions of key terms that will be used throughout the planning process. The Consultant Team and the Science Team should agree on these definitions early in the planning process to avoid confusion.

4.2 Approach to Technical Studies

An early milestone for interaction between the Science Team and the Consulting Team will be the planning of the approach to the technical studies based on Key Questions and Conceptual Models. This planning will include identifying the most critical data needs, refining conceptual models, setting the scope of work for the technical studies and choosing a set of modeling and analysis tools. The Science Team will review the Consultant Team's draft roadmap of the expected approach to the technical studies, that will be described in the Analysis Strategy and Model Selection Memorandum, the Alternatives Development Methodology Memorandum and other documents, early in the planning process. We acknowledge that the approach to the technical studies may be adaptive and thinking on key issues may change as the project evolves.

The technical studies should be performed in several phases with increasing level of refinement of alternatives and increasing detail of analysis as the planning proceeds. The anticipated number of screening levels and levels of refinement of alternatives should be outlined and rough schedules provided by the Consultant Team. The Science Team should be informed whenever the number of phases involved in the technical studies changes as the planning proceeds.

The Science Team would also like to receive information on the proposed scope of analysis in each phase of the planning process. When the scope is unclear, particularly for advanced phases of the planning process, the possible range of analyses should be outlined. For example, the Consultant Team may state that, in the screening of preliminary alternatives, it *will* apply a two- or three-dimensional hydrodynamic and sediment transport model and that it *may* apply this model to estimate long-term geomorphic change.

The Science Team wants to stress the importance of a candid discussion of the level of uncertainty associated with each proposed method of analysis, as well as the specific identification of model assumptions. Interaction between the Science Team and Consulting Team will help ensure that key uncertainties are identified and that assumptions made in technical analyses are appropriate. Therefore, we recommend that the Consultant Team outline the most important assumptions used in analyses and the key model parameters used in numerical models. If key uncertainties can feasibly be reduced by focused scientific studies within the schedule and budget of the Project, the Consultant Team should suggest appropriate studies. The Consultant Team should also consider how uncertainties may be propagated as more complex approaches are used and multiple modeling components are combined, e.g., hydrologic, sediment transport and geomorphic models.

The following information should be provided to the Science Team regarding any models that will be used:

1) Model name
2) Model dimension
3) Geographic model domain (location of boundaries)
4) Grid type and resolution

5) Processes that will be simulated with model
6) Key assumptions in model formulation
7) Input data required

The Consultant Team should provide a brief discussion of the reasoning behind the decisions made related to the modeling. Trade-offs between model accuracy and computational time and expense, or schedule concerns, should be explicitly discussed.

The Consultant Team should outline the expected approach for model calibration and validation. The expected phasing of the model calibration and validation should be described for individual components (modules) of the model(s) including hydrodynamics, sediment transport, contaminant transport, etc. For example, the Consultant Team may propose that a hydrodynamic model will be calibrated before the screening level alternative analysis is performed and validated prior to the preliminary alternative analysis. Model input data (e.g., initial and boundary condition data), calibration and validation datasets, and critical data gaps should be identified as early as possible.

Similarly, the Consultant Team should identify the data that will be used to specify and simulate baseline conditions. If simulations will be performed to estimate baseline conditions, the time period of this simulation should be identified.

Monitoring data from pilot projects that occur inside and outside the Project region may provide valuable data for model validation. The Consultant Team should identify potentially useful data and suggest additional monitoring of pilot projects that may be useful in model validation.

Sensitivity simulations can also help to identify key model parameters and the level of uncertainty in model predictions. Sensitivity simulations may be particularly useful for aspects of the study with a large degree of uncertainty, such as geomorphic simulations.

4.3 Contaminant Modeling

In order to minimize the harmful impacts of pollutants on at-risk species survival, it ultimately will be important to enhance our understanding of the fate/transport, biogeochemical cycling, and biological uptake of known pollutants (particularly mercury) in both the restored wetland areas and managed ponds. A short-term goal of the Consultant Team might be to examine the pro's and con's of existing pollutant transport and cycling models, to determine which approach might be adapted to the Project and linked to the hydrodynamic and sediment transport models that are already being developed. A longer-term goal should be to develop and incorporate an appropriate model platform as part of the medium- and long-term monitoring efforts that will be necessary to verify if pollutant uptake is being enhanced or mitigated as a result of wetland restoration and management efforts.

Three general types of mercury models have been used in ecosystem investigations to date. The first are those that focus on the transport of mercury through the system, as linked to hydrodynamics and sediment transport dynamics. The second are process-based models that include known biogeochemical reactions specific to mercury (e.g. methyl mercury production and degradation, photo-degradation of methyl mercury, etc.). The third are macro-biological models that focus on species-specific or food web level uptake of mercury into biota. Some past modeling efforts have attempted to combine either two or all three of these model types. Depending on the questions posed, particular model options would be more or less appropriate for answering specific questions and enhancing predictive capabilities regarding mercury cycling and bioaccumulation in the Project. Determining the appropriate approach for modeling contaminant transport, biogeochemical cycling and uptake for the Project should be an active point of discussion between the Consultant Team and the Science Team.

4.4 Modeling of Biological Processes

The primary focus of the modeling issues described above is hydrology and other physical processes; however, some of the key outputs for the modeling effort will be predictions of habitat development within restored ponds, as well as biological shifts in managed ponds, adjacent sloughs, and South Bay waters. The Consultant Team should identify how models will be used to predict habitat development and other biological processes. Some of the links between physical and biological processes are complex and not easily modeled, and there are large uncertainties associate with spatially explicit models. Therefore, numerical modeling may not be the only approach to consider in evaluating biological dynamics. More simplistic analyses may be useful, e.g., point-based modeling of habitat shifts or analyses of the historic development of similar restoration efforts in the Bay and elsewhere. The Consultant Team should identify what particular approaches will be the most useful for predicting shifts in the various biological processes that are analyzed.

Two of the key links between physical processes and habitat development are marsh-plain elevations (with temporal changes in elevation due to sediment accretion, sea level-rise, subsidence, and compaction) and tidal exchange. Both of these factors, along with the distance from the tidal source, affect the frequency and duration of tidal flooding at a particular location, which in turn will affect marsh vegetation. The Consultant Team should identify whether vegetation establishment will be modeled entirely based on appropriate water and tidal flat elevations, or if other factors such as salinity and biological components (germination and establishment rates, vegetative spread rates, etc.) also will be considered.

In modeling biological processes, there should be consideration of conservation biology principles, especially population dynamics of target species and the distribution of species at the landscape level. While there may be large uncertainties in linking models of physical processes and population dynamics, these processes should be evaluated. For example, if it is predicted that some salt ponds will be converted to a particular mix of habitats, what are the expected populations of target species that these new habitats would support? Some of the most poorly understood linkages that require further study are those relating the response of target species to specific habitats types and habitat features. Given this challenge, it will be necessary to use a range of tools and approaches in evaluating the wildlife responses to habitat changes, from simulation models to expert evaluation and simple population and life history analyses. An explicit evaluation of model uncertainty for this linkage also will be essential.

In addition to modeling changes in habitat development of restored ponds and the resulting population dynamics, it also will be important to characterize biological impacts on managed ponds, adjacent sloughs, existing fringing marshes, and on the larger South Bay ecosystem, including planktonic and benthic communities. For example, will managed ponds be net importers or exporters of phytoplankton or nutrients, and will ponds managed at lower salinities be subject to nuisance algal blooms? Thus, models of plankton dynamics should consider potential shifts in salinity due to restoration actions, as well as nutrients, temperature, contaminants, dissolved oxygen, and other water column factors. These models should consider shifts in dynamics in managed ponds, as well as in adjacent Bay waters. Furthermore, there should be some consideration of potential impacts on other species of interest within the South Bay, including salmonid species, harbor seal, clapper rail, black rail, salt marsh harvest mouse, and other identified species of interest.

4.5 Suggested Simulation Scenarios

Several scenarios, including those defining extreme boundaries of system behavior, will be simulated in the South Bay Salt Pond Restoration planning. In the Consultant Team's proposal, the proposed simulations include screening level simulations, preliminary alternative simulations and more detailed simulations for final scenarios. It may be appropriate to perform some of these analyses, particularly at the screening level, using simple methods such as spreadsheet calculations or GIS analysis instead of numerical models. All analyses of physical processes should consider the recommendations made in Hydrodynamic Modeling Tools and Techniques (Moffatt and Nichol 2003b).

Appropriate metrics, numeric targets for restoration, and numeric thresholds will be proposed by the Consultant Team in developing evaluation criteria for screening alternatives. For example, a metric for of non-native plant species might be the percent of non-native vegetation cover allowed (for example, no more than 10% cover by non-native species) in any particular pond (see Appendix A—Tidal Marsh Conceptual Model).

Whether numerical models or other analytical tools are used in the screening analysis, we suggest the use of conservative scenarios to identify potential issues and place bounds on the magnitude of potential impacts. Some key potential impacts/issues and ideas on conservative scenarios are given below. This list is not intended to exclude other potential impacts/issues, but covers some key potential impacts.

4.5.1 Flooding

A recommended approach for modeling flood events is discussed in Hydrodynamic Modeling Tools and Techniques (Moffatt and Nichol 2003b) and the hydrology of each slough, and relevant flood control projects, are discussed in Inventory of Water Conveyance Facilities (Moffatt and Nichol 2003a). The information and recommendations in those documents, and the flood management plans of the Santa Clara Valley Water District and the Alameda County Flood Control and Water Conservation District, should be considered in modeling efforts. Relevant issues include potential levee failure and overtopping and fluvial flooding.

Flooding from the ponds to urban areas adjacent to the ponds could occur as a result of levee failure or overtopping of levees due to high tidal elevation in the ponds with breached levees. A conservative levee failure scenario could be considered the failure of a large length of levee (perhaps due to a seismic event). Other conservative assumptions could include relatively high water level in the ponds and connection of landward ponds to other ponds via levee gaps. In

ponds with breached levees, overtopping of levees could potential occur at high water. In this case, a conservative scenario for overtopping would include the assumption of a full tidal range in the ponds, similar to the tidal range experienced in adjacent slough regions.
Creek flooding scenarios should focus on ways in which the restoration project could potentially increase flood risk, by increasing tidal elevations or decreasing cross-sectional area in some portion of the sloughs/creeks. Levee breaches would likely cause decreased high water elevation in sloughs but would also lead to increased low water elevation. Slough cross-sectional area is generally expected to increase as a result of breaching levees. However, while the cross-sectional area of a slough located downstream of pond breaches is increasing, the cross-sectional area upstream of pond breaches could decrease as a result of decreased tidal prism. This effect would probably be transient but could last several years. More subtle effects of the restoration could also influence flood risks. These effects include storage in the ponds, changes in effective drag due to changes in slough vegetation type (e.g., resulting from changes in slough salinity or inundation frequency), changes in bed forms and tidal prism, etc.

Flooding scenario simulations could be conducted for individual tributaries/sloughs of interest. Short duration simulations, for example, spanning a 100 year flow event, are appropriate. However, given uncertainties of geomorphic and biological evolution (e.g., vegetation type), multiple simulations will be required to span the potential future evolution of a tributary.

4.5.2 Tidal Flat Erosion

Tidal flat erosion is expected to occur if many ponds are opened to tidal action via breaches, allowing the ponds to serve as a substantial sediment sink. In order to estimate the maximum possible tidal flat erosion, an extreme scenario would be to breach levees to all ponds in the planning area. Several additional conservative assumptions should be made regarding sediment supply from tributaries, sediment properties, the "trapping efficiency" of the ponds, etc.

Tidal flat erosion may occur only near the project site or over a broader area. Therefore, we recommend that the model domain for these simulations encompass the South Bay. The time period of mudflat erosion may be quite long, suggesting that a long simulation period is required. Given that simulations of a large domain and long time period may be required, a simplified approach may be appropriate to place bounds on potential tidal flat erosion. In addition, connections in geomorphological processes across the model domain should be considered, e.g., evaluating the extent to which tidal flats and marshes operate as a single system, with erosion at one reach being compensated by accretion elsewhere.

4.5.3 Levee Erosion

Levee erosion occurs in managed ponds due to wave action. In ponds with breached levees, tidal velocities in the ponds may also lead to levee erosion. In addition to increasing the potential for catastrophic levee failure, levee erosion also increases maintenance expense. Therefore, a conservative estimate of the required levee maintenance is suggested. Levee erosion will be sensitive to levee properties, pond depth, tidal velocities and wind speed and direction (fetch).

While levee erosion and maintenance cycles generally span several years, substantial levee erosion could occur during episodic events. Therefore, several short-duration simulations of different conditions may be adequate to bound potential levee erosion.

4.5.4 Water Quality

The restoration actions will influence water quality in sloughs and adjacent portions of South Bay, in particular salinity. Slough and Bay water conditions could also affect pond water quality. Changes in salinity can be expected near discharge points of managed ponds and more widespread effects can be expected due to breaching levees. The effects from managed pond discharges will be largely proportional to the discharge salinity and flow. The effects from breached ponds should be largely proportional to the change in tidal prism in local slough and bay regions. Effects on salinity due to breaching may be particularly notable in regions with strong salinity gradients, such as Coyote Creek. Dissolved oxygen, DO, impacts could also occur from near discharge points as pond water with low DO is released into adjacent sloughs. Other potential water quality impacts from pond discharges (e.g., nutrients, contaminants) should also be evaluated.

Water quality effects will occur dominantly near discharge points of managed ponds and, potentially near levee breaches. These effects may vary substantial through the tidal cycle and diurnal cycle and will depend on weather and tributary flow conditions. Therefore simulations that resolve fairly local effects and span a large range of tidal and weather conditions are appropriate. Potential water quality effects near managed pond discharges were evaluated as part of the Initial Stewardship Plan (Life Science 2003b).

CHAPTER 5 - APPLIED STUDIES AND MONITORING

Chapter 5. APPLIED STUDIES AND MONITORING

This Project will be one of the largest wetland restoration programs in the United States. Synthesis of existing information and applied studies will be required to predict restoration outcomes and meet the planning milestones of the Project. A primary role of the Science Team will be to provide guidance on data needs and to identify the critical studies and monitoring needed to address those gaps. The Key Questions (Chapter 3) and Conceptual Models (Appendix B) will be used to identify uncertainties in the restoration process that require scientific inquiry. Applied studies and monitoring to address these uncertainties are essential to meet restoration goals through decisions that are scientifically defensible. The Science Team recommends that funding for studies and monitoring must be included as part of the planning and implementation of the Project. On the basis of other restoration projects and general guidelines for studies and adaptive management (Steyer et al. 2000, U. S. Government Accounting Office 2003), we recommend that the Project expect that 10-20% of the total budget will be required for science needs (Louis Berger and Associates 1997). Scientific funding must be at adequate levels to justify the Project costs and to support restoration actions that maximize resource values.

The process for collecting data should include involvement from the entire scientific and academic community. The greater San Francisco Bay area has a wealth of wetland restoration experts to draw upon representing a large number of major universities, several federal entities including the western region of the U. S. Geological Survey, the ecological research arm of the Department of Interior, state and local government agencies, numerous nongovernmental organizations, and consulting firms specializing in restoration. Other wetland specialists from across the nation have worked on restoration research in the estuary. Thus, we recommend that the wider scientific community be engaged in the applied studies and monitoring through a combination of cooperative agreements, competitive requests for proposals, and academic grant programs (See Section 5.5 and Appendix C).

The Science Team will play a major role in integrating applied studies and monitoring into the restoration process (See Chapter 6 and 7). We will work with the Consultant Team, PMT and other planning participants on incorporating existing relevant studies, developing topics for applied studies needed to support the Project, and recommending a monitoring framework that will promote effective adaptive management.

5.1 Existing Scientific Information

A summary of existing species and community information was produced for the estuary habitat goals project (Goals Project 1999, Goals Project 2000). Siegel and Bachand (2002) developed an initial compilation of scientific data specific to the salt pond restoration, under contract to the California Coastal Conservancy. PRBO Conservation Science has developed preliminary scenarios that model the effect of converting salt ponds to tidal marsh habitat on bird populations (PRBO Conservation Science. 2004. An effort should be made to synthesize and make available all data relevant to the restoration process, including compilations such as the San Francisco Airport Runway Reconfiguration Program report (URS Corporation 2003). Empirical data should be used to create and validate models used to predict Project outcomes.

Restoration actions that alter physical processes will lead to changes in habitats, which in turn, result in a wide range of responses by different species (see Conceptual Models in Appendix B). Although simulations will depend on existing models relating physical processes to habitats, the link between habitats and populations, especially target organisms such as species of special concern, are poorly developed in the scientific literature. Thus, one goal of the scientific studies for the Project will be to better understand those relationships. Other Key Questions that require examination are included in Chapter 3.

5.2 Applied Studies

5.2.1 Introduction

The primary goal of applied studies in the restoration process will be to reduce uncertainty about critical cause-and-effect linkages driving the development of ecosystem functions (see Key Questions and Conceptual Models). Restoration will occur over many years, which may be divided into three major periods: planning, initial restoration, and phased restoration. We strongly recommend that planning and initial phases include pilot projects that test hypotheses to help evaluate scenarios envisioned for future phases. Pilot studies should also evaluate monitoring techniques for assessing the ecological effects of restoration actions at pond, slough, and regional scales. Monitoring of biological resources should begin as soon as possible and continue through the restoration process so that adaptive management principles can be applied.

5.2.2 Investigation Scale

At the smallest scale, the 53 former salt- evaporation ponds varying from 12 to 276 hectares (30 to 680 acres) will be affected by the Project (>6000 hectares or >15000 acres total). Applied studies will include baseline studies of existing characteristics, examination of pilot restoration work, and comparisons with other reference wetlands. Very little work has been done to understand the resource value of ponds in tidal areas, especially unique wetlands such as hypersaline ponds. Characteristics of ponds with high resource value will be used to help determine restoration management directions, especially the optimal mix of habitat types. There are many historic or ongoing restoration projects in the region; thus, studies of these reference projects should be one of the first tasks conducted by the Project to assess direct restoration actions. We recommend that historic photographic analysis be done on some of the previous levee breach projects to gain insight into rates of restoration, i.e., Outer Bair Island, Cooley Landing.

At the slough or pond system scale, the Project involves three former salt-production complexes: Alviso, Baumberg, and Redwood. Although most ponds were acquired in Alviso and Baumberg, only a few ponds were included from the Redwood system. Each of these systems has distinct characteristics, but studies of physical and ecological processes may need to consider the entire system. For example, the Alviso system includes the drainage from the Guadalupe River through Alviso Slough. It will be valuable to integrate restoration along that river with the South Bay restoration actions that may require studies of both the pond and riverine habitats.

A unique aspect of this Project is that it will have an effect on the ecology of the entire South Bay region, and perhaps beyond. That is, restoration will not only affect individual restored ponds, but also the mosaic of habitats available in the entire South Bay. Thus, a critical area of scientific investigation will be developing landscape-scale habitat predictions. For example, restoring tidal marshes in the majority of a system may result in concentrating species such as shorebirds onto a single pond, resulting in elevated rates of predation or disease. The effects of restoration may extend to even larger scales such as the watershed, estuary, or the west coast (especially for resources such as migratory birds). For certain species, for example western sandpipers, the South Bay Project has the potential to impact global populations. Studies at larger scales should be encouraged but will not be a primary science focus for the restoration process.

5.2.3 Hypothesis Testing

Cause-and-effect relationships will be examined most efficiently through testing of specific hypotheses. For example, we may want to answer the question, "Do shallow ponds become anoxic during the summer?" This could be examined by experimentally manipulating water levels in ponds. However, conditions in the Project area will likely not allow for a rigid experimental design for many applied studies. Use of existing ponds or sites outside of the Project area may be valuable to provide replication.

5.2.4 Pilot Projects

Some ponds may be breached during the planning or initial phases of the Project. Pilot projects, whether opportunistic or planned, should be incorporated into this phase as a valuable scientific tool for examining issues that will be encountered during the phased restoration. Projects that provide linkages to address a number of questions simultaneously should be encouraged, integrated with the adaptive management framework. Pilot projects conducted later during the phased restoration, will not be as valuable as those conducted prior to the major restoration work. In addition, sites outside of the Project area, but preferably within the South Bay region, should be used as reference sites. Other projects, such as ongoing restoration at Eden Landing Ecological Reserve may provide valuable insights into the likely responses of the local ecosystem to restoration actions. Pilot projects should include detailed experimental designs with appropriate statistics to examine differences.

For example, early pilot projects can be used to help to validate models that predict the effects of pond salinity reduction. Initial efforts will reveal the potential problems of invasive *Spartina alterniflora* colonization of marshes. Early projects will allow empirical studies of mercury methylation to predict contaminant risks to wildlife. Pilot restoration efforts will allow measurement of changes in sediment balances, and lead to better understanding of trade-offs between sediment in restored ponds and loss of slough habitats or mud flats. Restoration of marshes with the use of dredge materials could be tested to see if fully functional marshes develop (see Williams and Orr 2002). Studies can also be designed to investigate the role of pond location in the landscape on salinity levels internal and external to the pond, habitat change and species dispersal.

5.2.5 Modeling

Modeling will be a valuable tool to predict outcomes of the restoration, especially for complex outcomes that may not be measured empirically. For example, sea-level rise may result in reduction of marsh plain areas, but predicting the magnitude of the change will require predictive models developed from regional or global scale models. Every effort should be made to include or obtain data to compare with model results to increase confidence in the simulations.

In addition, modeling efforts that examine linkages from habitats to target populations should be considered (See Chapter 4, section 4.3). Most restoration projects try to model marsh development, but not the linkage to the species of concern, an approach commonly described as "build it and they will come." A more comprehensive approach should be adopted to decide the extent and distribution of habitats that will support final target populations. Models such as habitat conversion models (PRBO Conservation Science, http://www.prbo.org/cms/index.php?mid=131&module=browse), population viability analyses (PVAs), and other habitat preference models should be included in the proposed applied studies. Spatial analyses with Geographic Information Systems should be encouraged to examine landscape questions.

5.3 Monitoring for Adaptive Management

5.3.1 Introduction to Monitoring

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 is 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.

(Callaway et al. 2001)

Wetlands are very dynamic systems and tidal restoration is an uncertain science. Thus, a regular monitoring program must be incorporated in all phases of the work to allow for adaptive management to improve the Project as it progresses, examining uncertainties highlighted in the conceptual models (Chapter 2, Appendix B). Design of the monitoring program will require balancing the need for data to determine changes or trends against budget constraints. In addition to monitoring to assess ecological progress, the monitoring program will be designed to address regulatory requirements such as the Project Biological Opinion or Discharge Permit. Monitoring will provide the information to create and sustain a wetland landscape that maximizes resource value but must be flexible enough to make mid-course adjustments (Callaway and Sullivan 2001).

5.3.2 Monitoring at Different Scales

Most monitoring of wetland restoration occurs based on the needs of a particular site in accordance with project funding, and they often lack evaluations of larger spatial scales. Given the large scale of this Project, monitoring must include the slough and landscape levels. For example, monitoring at the pond level will need to include parameters that link pond changes to slough and landscape changes. Monitoring at the slough (multiple pond-system) scale should include measures of how restoration actions affect the surrounding area, effect salinity discharges, change channel morphology, effect slough sinuosity or geometry, and respond to variation in sediment supply. At the landscape, or regional, level, monitoring must examine changes in the landscape mosaic, especially habitat connectivity, wetland fragmentation, and corridors.

5.3.3 Monitoring Parameters

A detailed monitoring plan will be developed based on performance standards (or target conditions) for specific sites, as well as for performance of the entire Project. There may also be opportunities to expand the monitoring effort to include fundamental ecosystem processes. (Table 5.1). Through the course of the Project, prompt data analysis and dissemination will be essential for adaptive management and to guide further monitoring based on trends observed in the data. Timelines should be included in the monitoring program to ensure prompt completion while allowing adequate time for accurate data processing and analysis.

Table 5.1. Examples of potential parameters to sample inside and outside of a restoration site (see Callaway et al. 2001, Neckles et al. 2002, Warren et al. 2002).

Topic	Parameters
Hydrology	flow rates, current velocity, inundation regimes, ground water levels
Sediments	volume calculation, bathymetric change, accretion, suspended sediments concentrations, pollutant concentrations, wind patterns and estuarine circulation, wave energies
Water Quality	water temperature, dissolved oxygen, salinity, pH, turbidity, variation of salinity and temperature with depth, pollutant concentrations
Geomorphology	bathymetry, channel development, channel cross-sections, levee composition, sedimentation dynamics.
Soils	soil moisture, bulk density, soil texture, pore water salinity, soil pH, soil oxygen-reduction (redox) potential, organic matter content, nutrient content, and sediment contaminant load
Vegetation	colonization and dispersal, composition, species richness, percent native vegetation, percent cover, stem counts, invasive vegetative cover and distribution, density, canopy architecture (height structure), above- and below-ground biomass, productivity estimates, plant nutrient pool, algal abundance and productivity
Invertebrates	species composition, benthos, soil infauna, nektonic invertebrates (biomass), survival, breeding success, dispersal
Fishes	species composition, length, growth rate, totals standardized by unit of effort, species classifications (native, non-native, resident, transient), diet (gut content), survival, breeding success, dispersal
Birds	species composition, bird density, species richness, behavior, habitat, feeding guild, breeding status, survival, breeding success, dispersal
Small Mammals:	species composition, species richness, density, sex, age, reproductive condition, survival, breeding success, dispersal
Large Mammals	population and distribution changes, changes in food species, effects of restoration Project construction, survival, breeding success, dispersal
Integration	food webs (predator-prey), habitat associations, water quality effects on vertebrate prey, trajectories for specific wetland functions, environmental education and public support

5.3.4 Monitoring Design – measuring temporal changes and trends

Monitoring the restoration process requires repeated sampling of biophysical parameters to measure change. The ability to discern spatial differences depends on the number of samples, while the ability to determine trends through time depends on sample frequency. In the South Bay tides are an important natural source of variability that must be taken into account in designing the monitoring program. For some parameters it may be necessary to sample at a consistent phase of the tide, so that long-term trends can be separated from tidal variability. For other parameters it may be necessary to assess variability over the semidiurnal tidal cycle.

One method to detect potential environmental impact in heterogeneous environments is a Before-After, Control-Impact (BACI) framework (Stewart-Oaten et al. 1986, 1992; Underwood 1992). The BACI design compares pre- and post-impact conditions at a study site and uses multiple nearby control or reference sites to account for natural variability. It allows for comparisons in reference systems over time to determine the rate of change in relation to the restoration activities. It also helps distinguish temporal effects unrelated to the restoration activities from those related to the project (U.S. EPA 2002). The BACI design is a powerful analytical tool to help analyze the impact of restoration activities; however, it can overestimate changes caused by the restoration (Type I error). The BACI design assumes that trends between the impacted and control sites are created by the Project, i.e., not attributable to natural differences between the two populations (Smith et al. 1993).

5.4 Relationships to other Research and Monitoring Programs

Research and monitoring initiated by the Project will take place in context of a number of national and regional planning efforts (Goals Project 1999) and should be designed to complement ongoing monitoring and research in the region. Research is being conducted in association with the Priority Ecosystem Science Program (formerly Place-based Program) of the U. S. Geological Survey. Monitoring of the Project area may use techniques currently under investigation in the estuary such as the Integrated Regional Wetland Monitoring (IRWM) project in the North Bay and Delta to examine long-term monitoring at different scales, or the California Rapid Assessment Method (CRAM) to examine wetland trends and stressors. Similarly, the EPA Environmental Monitoring and Assessment Program (EMAP) rapid indicators monitoring program assesses wetlands on a broad-scale and may provide complementary assessment methods. The Project monitoring will complement existing data collection in other parts of the estuary by the CALFED Ecosystem Restoration Program Plan (ERPP), including BREACH I and II. Integration with other conservation plans will also be important. For instance, the U. S. Shorebird Conservation Plan and the Southern Pacific Regional Shorebird Plan have specific monitoring, research and conservation recommendations that will be relevant to the Project. Integration with the San Francisco Bay joint Venture should also be encouraged and implemented.

5.5 Reporting of Project Findings

To help assure continued public and stakeholder support for and participation in the Project over the long term, it will be very important to provide routine access to the technical information generated over the life of the South Bay Salt Pond Restoration Project. This is best accomplished through timely publication of information and findings in a variety of print and web-based outlets. We therefore recommend that the Project encourage the routine compilation, synthesis, and publication of results from monitoring and research programs, GIS and computer modeling projects, and permitting and regulatory actions in formats that are accessible and understandable to all interested participants, from research scientists, resource managers and decision-makers, to the lay public. The frequency of reporting, from research publications in scientific journals to news releases and fact sheets useful to the public, will be determined by the nature of work completed and the needs of the individual Restoration Project participants and the larger community for the information generated. All reports produced under the auspices of the Restoration Project should be made available on the Project website.

In addition to periodic scientific, management, and public interest reports prepared and released as the studies are completed, it may be appropriate to prepare an Annual Restoration Project Report that provides all stakeholders, including managers, the public and legislative staff, with the following types of information: 1) a summary of Project actions taken during the year; 2) status of Restoration Project goals and objectives; 3) highlights of what has been learned, both positive and negative, during the year; and 4) a fiscal summary.

5.6 Database Management

Data handling and storage will follow Federal Geographic Data Committee (FGDC) metadata standards. Field data will be recorded on data sheets, notebooks, or personal digital assistants and entered into digital files stored on computer hard disks. All data will be compiled, QA/QC checked, and archived at facilities with mirrored drives, tape backup, and redundant copies at a different location. Field data will be incorporated into a geographic information system (GIS) for spatial analyses of point, line, or polygon coverages. All field data will be collected with spatial references of latitude and longitude coordinates determined from digitized maps or Global Positioning System (GPS) units with Wide Area Augmentation System (WAAS) correction for <5 m accuracy if possible. Data will be projected into Universal Transverse Mercator (UTM), Zone 10, with NAD83 horizontal datum. Elevation data will be tied to the vertical datum of NGVD29 or NAVD88, and water depths and corresponding bathymetry will be adjusted to NGVD29.

5.7 Competitive Grant Program

5.7.1 Introduction

It is the Science Team's strong belief that the South Bay Salt Pond Restoration Project would greatly benefit from the establishment of programs that make funding available, on a competitive basis, for targeted new research directed toward providing the information necessary to make well-informed restoration action decisions. Such funding, to be provided by the sponsors of the Restoration Project (e.g., California Department of Fish and Game, U.S. Fish and Wildlife Service, the Coastal Conservancy, US Army Corps of Engineers, and appropriately funded stakeholders), should be made available through a competitive research grant program that the Science Team would be willing to help coordinate. Such a program could be designed to operate at one or both of two levels: (1) a more modest program directed specifically to support graduate student applied studies, or (2) a larger program designed to attract proposals from the larger community of scientists and engineers, irrespective of institute or agency affiliation.

5.7.2 Academic Research Program

The Science Team is particularly interested in encouraging the involvement of the academic community in salt pond research and monitoring activities. The Team's motivation for recommending a funding program for financial and logistical support of graduate students and postdoctoral research associates is that sustained and vigorous interaction between resource managers and local university-based scientists can result in relatively less expensive research and monitoring studies that are designed specifically to be responsive to agency and stakeholder needs and management strategies. A draft of a student applied studies funding program is attached to this report (Appendix C.1).

5.7.3 Focused Research Program

The Science Team also recognizes that substantial advancements in our understanding of the multiple processes that determine how wetlands function and how restoration actions may or may not succeed in achieving desired goals and objectives may not be fully achieved without larger-scale, multidisciplinary approaches to key problems. Such approaches will require high levels of experience and expertise and access to more extensive research facilities and capabilities and would benefit from a larger competitive grant funding mechanism. A draft of a competitive funding program is attached to this report (Appendix C.2).

CHAPTER 6 - SCIENTIFIC GUIDANCE AND PEER REVIEW

Chapter 6. SCIENTIFIC GUIDANCE AND PEER REVIEW

6.1 Introduction

In order to achieve high levels of reliability and credibility, all scientific aspects of the South Bay Salt Pond Restoration Project, including syntheses of existing knowledge, proposals for modeling and pre-project sampling, research and monitoring studies, and recommendations for specific final restoration plans, will be guided by input from the Science Team and will be subject to rigorous independent technical review.

The Science Team recommends that it be tasked with providing advice, guidance, and review of the scientific work of all Project participants – consultants and other scientists and engineers – on an ongoing basis throughout the course of the Project. The Science Team should also be tasked with coordinating and managing a peer-review process, involving anonymous external peer reviewers, to provide for the review of technical reports describing the results of scientific and engineering studies and other analyses that have been commissioned by Project sponsors.

6.2 Science Guidance

The Science Team will serve as an independent body in evaluating the ongoing work of consultants. We envision that the consultant team at regular intervals will make presentations to the Team during which, for example, proposed work strategies will be described, initial results presented, and draft conclusions reached. The Team will provide input and critique to the consultant team with the expectation that the Consultant Team will provide written responses to any concerns and suggestions raised, and that subsequent drafts of analyses and reports will reflect consensus decisions regarding those concerns and suggestions.

We will work with the consultant team in the development of a work timeline that incorporates periodic Science Team review of progress and preliminary products, as well as regular face-to-face meetings.

In the event that disputes over technical issues arise among the participants of the Project Management Team or the Stakeholder Forum, the Science Team can be tasked with making and presenting its own finding and recommendations on the disputed issues. The Science Team will arrange consult with outside experts to resolve the issue, if necessary.

6.3 Peer Review

The Science Team will establish a process for, and supervise the peer review of draft technical reports resulting from investigations that have been funded by the Project. Each such report will be sent to at least three technical experts who will be asked to provide written critiques. The author(s) of the report will then be requested to revise the report in accordance with the recommendations of the reviewers and/or to provide a rebuttal in those cases in which the author disagrees with a reviewer's suggestion or criticism. The Science Team will encourage authors of those reports that have received favorable review to publish the study results in broadly accessible scientific print or electronic journals such as the new on-line journal, *San Francisco Estuary and Watershed Science* - http://repositories.cdlib.org/jmie/sfews/ - to ensure broad and timely dissemination of Project information. This peer review process may require the establishment of a schedule of honoraria for reviewers, based on a sliding scale related to the size of the report.

The Science Team is also willing, as requested, to coordinate the review of any draft reports substantially technical in nature that are prepared by the Project Management Team and the Stakeholder Forum.

CHAPTER 7 - SCIENCE TEAM ACTIVITIES AND TIMELINE

Chapter 7. SCIENCE TEAM ACTIVITIES AND TIMELINE

The previous chapters of this Science Strategy describe processes for generating the key questions, data needs, modeling, and for the peer review of findings. However, a critical part of the Science Strategy is to make the work generated by the Science Team available to the other groups in the planning process.

Incorporating the scientific and technical guidance into the Project requires regular interaction between the Science Team and all the other key participants in the Project—the NSP, PMT, the Consultant Team, the regulators, scientists/experts, and the public.

Essential features of this process are:

1. Regular meetings of the Science Team with the Consultant Team and the PMT to:
    a. provide scientific input at every stage of the planning process,
    b. identify critical research questions and data needs that need to be addressed to meet current and up-coming milestones,
    c. identify pilot projects and research opportunities to address uncertainties and data needs, and
    d. identify those research opportunities best suited for students and/or scientists and other experts.

2. Science Team peer review of
    a. consultants' approaches to addressing planning tasks,
    b. draft reports, and
    c. final technical documents and reports.

3. Preparation of additional guidance documents by the Science Team on specific topics, such as Decision Criteria for Selecting Sites for Restoration Action (in preparation).

Mechanisms that have been established to ensure regular connections between the Science Team and the planning process participants are as follows:

- The Science Team will expand from its current 6 members to 12-15 members by May 2004 in order to bring in a wide range of experts to assist in guidance and peer review. The expanded Science Team will meet, on average, every other month.
- The Science Team will meet regularly with the Consultant Team and others working on scientific/technical aspects of the planning process.
- The Lead Scientist will meet regularly with the PMT in order to exchange information and ideas between the PMT and the Science Team.
- The Lead Scientist will meet regularly with the public (through the Stakeholder Forum and Working Groups) in order to exchange ideas between the public and the Science Team.
- Other Science Team members will meet with Working Groups (public groups) to hear their issues and provide scientific input and review.
- The Lead Scientist/Science Team will meet twice a year with the National Science Panel to present products and progress.

Table 7.1 contains a 2003-2004 Timeline for Science Team interactions with the other key players.

The process of scientific review and information sharing described in this Science Strategy provides for scientific direction throughout Project planning and initial implementation, especially at critical junctures in the process. As noted above, the Science Team will meet with the PMT and Consultant Team to identify, well in advance, the critical questions, uncertainties and data needs that must be addressed for each planning milestone. In addition, the chapters of this Science Strategy provide initial guidance for each milestone as follows:

Milestone	*Key Relevant Chapter(s)*
1. Analyze Existing Conditions	Ch. 2 & Appendix A: Conceptual Models Ch. 3: Key Questions Ch. 6: Peer Review Ch. 7: Science Team Activities
2. Develop Restoration Goals and Objectives	Ch. 2 & Appendix A: Conceptual Models Ch. 6: Peer Review Ch. 7: Science Team Activities
3. Develop Strategy for Integrating Flood Management, Public Access and Habitat Restoration	Ch. 2 & Appendix A: Conceptual Models Ch. 3: Key Questions Ch. 6: Peer Review
4. Develop Alternatives for Habitat Restoration	Ch. 4: Modeling and Analyses Ch. 5: Studies and Monitoring Ch. 6: Peer Review Ch. 7: Science Team Activities
5. Conduct Technical Analysis of Alternatives	Ch. 5: Studies and Monitoring Ch. 6: Peer Review
6. Conduct Environmental Review of Alternatives	Ch. 6: Peer Review Ch. 7: Science Team Activities
7. Select Preferred Alternative and Design Selected Alternative	Ch. 2 & Appendix A: Conceptual Models Ch. 4: Modeling and Analyses Ch. 7: Science Team Activities
8. Develop a Monitoring, Maintenance, and Adaptive Management Plan	Ch. 2: Key Questions Ch. 5: Studies and Monitoring Ch. 6: Peer Review Ch. 7: Science Team Activities

Table 7.1. Science Team Activities Timeline

Science Team Task	Year 2003			Year 2004											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Prepare Draft Science Strategy/Conceptual Models															
Peer Review Draft Strategy/Models															
Revise Draft Strategy/Models															
Meet with National Science Panel (2 times/year)															
Revise Science Strategy/Models															
Expand Science Team/Peer Review Panel															
Expanded Science Team Meets															
Meet with PWA as Needed (1-2 times/month)															
Peer Review of Documents (irregular)					*	*	*	*	*	*	*	*	*	*	*
Meet with PMT (1-2 times/month)															
Meet with Stakeholders Forum															
Meet with Stakeholders Working Groups (irregular)					*	*	*	*	*	*	*	*	*	*	*

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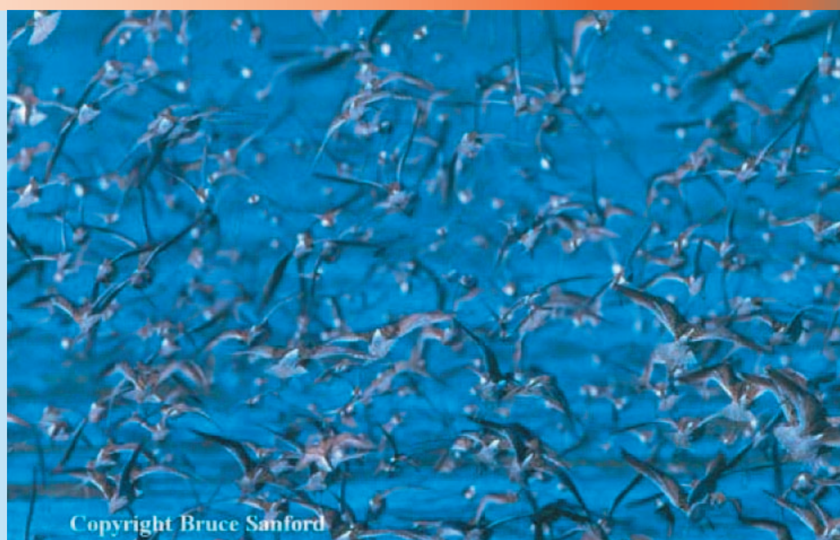
APPENDIX A - ENVIRONMENTAL SETTING FOR THE REGION



Appendix A. ENVIRONMENTAL SETTING FOR THE REGION

A.1 Overview

The South Bay Salt Pond Restoration Project (Project) region consists of approximately 6,100 hectares (15,100 acres) of ponds in three distinct regions bordering South San Francisco Bay: the Alviso Complex, Baumberg Complex and Redwood City Complex (Figure A.1.1). The Project region consists primarily of former wetlands that were diked off from the Bay as early as the 1860s (Siegel and Bachand 2002). Creation of the levees and other actions in the Project region had large effects on the ecosystem of San Francisco Bay. The primary effect on the landscape was loss of marsh habitat and creation of pond habitat used by many bird species. Restoration of the ponds also will have sizeable effects on physical and ecological processes in San Francisco Bay. In this section we provide an overview of the physical processes and ecological setting in South San Francisco Bay. Our goal is to provide a context for the discussion of the restoration actions, the natural processes (or driving forces) involved in the restoration process, and the potential negative impacts to the system. More detailed information is available in several publications, including the Baylands Ecosystem Habitat Goals Report (Goals Project, 1999), the Baylands Ecosystem Species and Community Profiles (Goals Project 2000), the South Bay Salt Pond Restoration Feasibility Analysis (Siegal and Bachand 2002), the San Francisco Bay Plan (San Francisco Bay Conservation and Development Commission 1968, amended 2003), the Water Quality Control Plan (San Francisco Bay Regional Water Quality Control Board 1995), and the South Bay Salt Ponds Initial Stewardship Plan (Life Science 2003a).

The San Francisco Estuary is the largest estuary on the west coast of North America and provides a unique habitat for a great diversity of estuarine species. Although it continues to support a vital and complex ecosystem, it has been significantly altered by extensive urban development on its shores, diking of its original wetlands, and large-scale diversion of fresh water from its watershed. These changes to the San Francisco Estuary and its watershed have degraded water quality, dramatically reduced marsh area, changed the amount and timing of freshwater inflow, changed sediment loads, reduced the diversity, distribution and abundance of native species, introduced non-native species, and caused other detrimental effects to the estuarine ecosystem. In this context, the Project provides an important opportunity to improve the ecological health of the Estuary.

The environmental setting of the Project region is presented in several parts. First, we discuss the physical setting and processes that influence the development of tidal marsh. Then, we briefly summarize the ecological setting of South San Francisco Bay, including the Project region. Next, we survey the anthropogenic impacts that have impaired the ecology of South Bay. Lastly we discuss the proposed operation of the ponds during the planning of the Project.

A.2 Physical Setting

San Francisco Bay is an ancient river valley that has filled due to rising sea level over the last 10,000 years (Atwater 1979). South San Francisco Bay (South Bay) is the portion of San Francisco Bay that abuts Central Bay “on the western side at Coyote Point, and on the eastern side at the San Leandro Marina” (Goals Project 1999). The South Bay is a shallow embayment, with an average channel depth of 10 m, and broad shallows and tidal flats with an average depth of 2 m (MLLW). Fifty-two percent of the area of South Bay has a depth less than 1.8 m at

MLLW (Cheng and Gartner 1984, Conomos et al.1985). The broad shallow shape of the Bay reflects its geomorphic origin as a river valley.

San Francisco Bay is characterized by mixed semidiurnal tides. In South Bay the tidal range increases with distance from the Golden Gate Bridge, from 1.5 m at Hunters Point to 2 m at the Dumbarton Bridge (Walters 1982). Currents in South San Francisco Bay are primarily driven by the tides. Tidal currents reach a maximum of approximately 1 meter per second in the channel and are much lower over the tidal flats. Wind-driven circulation can also be important, particularly in the shallows. Circulation can be influenced to a lesser extent by freshwater inflow and associated density gradients.

During the winter wet season, fresh water flows into South Bay from local watersheds including the Guadalupe River, Alameda Creek and Coyote Creek. Since the 1950s freshwater inflows from the local watersheds have decreased due to the construction of dams. During the same period the discharge of treated wastewater has increased, and currently accounts for a significant portion of the freshwater inflows to the system, particularly during summer. A third source of freshwater to the South Bay is outflow from the Sacramento-San Joaquin Delta, which can enter South Bay from Central Bay. The importance of Delta outflow as a source of freshwater to South Bay has not been quantified but may be large during high Delta outflow conditions.

Variations in freshwater inflow to South Bay result in a seasonal trend with higher salinity during the dry summer and fall seasons, and lower salinity during wet winter and spring conditions. During typical summer and fall conditions South Bay is well-mixed vertically due to the low freshwater inflow, in contrast to the northern reach of the estuary which is intermittently stratified. During summer, salinities are typically approximately oceanic (33 ppt) throughout South Bay and high rates of evaporation can produce hypersaline conditions. During winter, salinity and the degree of stratification are more variable and are strongly influenced by freshwater inflows from local watersheds.

The availability of sediment within the system depends on the overall sediment budget of South Bay as well as the internal sediment dynamics, which are driven by hydrodynamics. The sources of sediment to South Bay are the local watersheds and, episodically, Delta outflows. As with freshwater inflows, the relative importance of Delta outflows as a source of sediment has not been quantified. Sediment can be carried out of South Bay through the Golden Gate by tidal currents, or it can accumulate on mudflats and adjacent wetlands. Opening salt ponds to tidal exchange will create a new sink of sediment for South Bay. Sediment within the South Bay is continually resuspended, producing high turbidity in the water column. Wind waves resuspend sediments over the broad shallows, and tidal currents erode sediments in the channels (Schoellhamer 1996). Once in suspension, these sediments are internally redistributed by tidal and wind-driven currents. When ponds are opened up to tidal exchange, flood tides will carry suspended sediment into them, and much of this sediment will settle out in the ponds due to the low velocities there.

The development and retention of wetlands in San Francisco Bay is largely controlled by relative elevation, which is affected primarily by sea-level rise, subsidence, and sediment supply. Whether the area of wetland increases or decreases over time depends on whether sediment supply is greater or less than that needed to compensate for the rising sea level and subsidence. The importance of these factors is reflected in the geomorphic evolution of San Francisco Bay: most of the tidal flats and tidal marsh surrounding the Bay developed after the rate of sea-level rise slowed down about 6,000 years ago (Atwater 1979). Marshes in the South Bay are thought to be about 4,000 years younger than in the Delta, originating within the last 2,000 years (Atwater et al. 1979). These same factors, in conjunction with colonization by vegetation and higher trophic level organisms, will govern marsh restoration.

The Project region borders several tidal sloughs. All of these sloughs are strongly influenced by tides in South Bay and contain a much greater volume of water, and larger surface area, at high water than low water. Several sloughs receive substantial freshwater input from creeks and wastewater treatment plants. Salinity in these sloughs ranges from oceanic to fresh water, and can vary substantially over the tidal cycle and with depth. Many of the tidal sloughs are depositional environments because the tidal prism upstream of the sloughs was reduced when salt ponds were created. Several sloughs are dredged for flood control purposes. The sloughs in the Alviso Complex region are Coyote Creek, Mud Slough, Artesian Slough, Alviso Slough, Guadalupe Slough, Stevens Creek, Mountain View Slough and Charleston Slough. Coyote Creek receives substantial inflow from its watershed, and Alviso Slough receives flow from the Guadalupe River watershed. Artesian Slough receives discharge from the San Jose municipal wastewater treatment plant. The tidal sloughs near the Baumberg Complex are Alameda Flood Control Channel, also known as Coyote Hills Slough, Old Alameda Creek, Mount Eden Creek and North Creek. Alameda Creek, the largest tributary to South Bay, drains into Alameda Flood Control Channel. The largest tidal slough near the West Bay Complex is Ravenswood Slough, which receives minimal freshwater input. These sloughs are discussed in more detail in the South Bay Salt Pond Restoration Project Inventory of Water Conveyance Facilities (Moffatt and Nichol Engineers 2003a).

A.3 Ecological setting

The South Bay includes a variety of habitat types that have been outlined and classified by a number of previous studies (San Francisco Estuary Institute 1999; Josselyn 1983; Meiorin et al. 1991; Goals Project 1999). With minor modifications, we have adopted the approach of habitat classification from the Habitat Goals Project (Goals Project 1999) shown in Table 2.1. Because the Habitat Goals Project focused on the entire San Francisco Bay region, some habitats are not likely to occur in the Salt Pond Project Area.

The distribution of these habitats is influenced primarily by the degree and frequency of tidal inundation and the salinity regime. Frequency of inundation is determined by elevation relative to sea level, and salinity is affected by local freshwater inputs, as well as total freshwater inflows to the entire Bay. Historically there was a complex spatial mix of habitat types across the South Bay, with a range of salinities and elevations relative to mean high water (MHW). Substantial shifts in habitat have occurred due to diking, filling of Bay habitats, and changes in freshwater inflows.

Bay and channel habitats (both deep and shallow) are subtidal, whereas tidal flats (mudflats) and tidal marshes are within the intertidal range. Tidal flats are uncovered by the low tides and remain unvegetated, and are at the lowest intertidal elevations. Tidal flats support an abundance of benthic invertebrates that are key food resources for the large shorebird and waterfowl populations that migrate though the Bay. In addition, a number of fish species use both subtidal and intertidal habitats, such as topsmelt (*Atherinops affinis*) and longjaw mudsucker (*Gillichthys mirabilis*).

At slightly higher elevations, salt marsh habitats are found. *Spartina foliosa* (cordgrass) dominates the low marsh and *Salicornia virginica* (pickleweed) dominates the mid-marsh plain although older marshes are far more complex and species rich (Josselyn 1983; Goals Project 1999, 2000). Natural marshes are characterized by a complex network of tidal channels that connect these habitats to adjacent sloughs, tidal flats, and the Bay. The branching and sinuous channels provide a passage for tides to deliver sediment and nutrients to intertidal marshes, as well as passage for fish and the dispersal of other organisms. In South Bay, the low marsh supports an important native special status species, the California Clapper Rail (*Rallus longirostris obsoletus*), and the higher marsh supports another native special status species, the salt marsh harvest mouse (*Reithrodontomys raviventris*). In well-developed marshes, marsh pannes form at the mid- and high-marsh elevations. These pannes are shallow natural ponds that may become very saline and often support little vegetation. Moving toward shore, mid-elevation marsh grades into high marsh above mean higher high water. *Grindelia humilis* (marsh gum plant) is a showy indicator of this zone. Finally, the transitional wetland-upland ecotone occurs at the marsh's highest fringe. This is a very important component of the tidal marsh system, providing refuge for non-aquatic species at highest tides (Goals Project 1999). *Baccharis pilularis* (coyote bush) is a common plant here. The ecotone may grade directly into terrestrial habitats, especially non-native grasslands, or may consist of rare native communities such as moist grassland, vernal pool or willow grove habitats (Goals Project 1999).

In areas where freshwater inputs are significant, brackish marsh develops at similar elevations as tidal salt marsh, with the vegetation dominated by *Scirpus* species, as well as a wide mix of other species (Baye et al. 2000). These areas are known to support a range of nesting bird species, such as ducks (gadwall, cinnamon teal) and colonial waterbirds (black-crowned night heron). Here again, the marsh-upland ecotone is an important habitat, supporting nesting species and amphibians. At even lower salinities, freshwater marsh forms, with *Typha* species dominating. Freshwater marshes may be found in both tidal and non-tidal areas, but are uncommon in the South Bay, except very close to wastewater treatment plant outfalls.

Managed marshes are also within the intertidal range, but the tidal hydrology is manipulated by water control structures. These marshes may be salt, brackish or freshwater depending on the salinity of the flooding waters. The objectives of managing hydrology for these marshes vary widely, from providing wildlife habitat to flood control. However, in all cases, the tidal range of the managed marsh is reduced, as is the opportunity for sediment input and biological connectivity to adjacent habitats.

Today, the habitats provided by salt ponds are an important part of South Bay ecology. Salt ponds support a great diversity and abundance of species, especially migratory shorebirds and waterfowl that have lost habitat elsewhere or find important foraging and roosting habitats in the salt ponds (Warnock et al. 2002). Salt pond conditions have typically been maintained by salt-producing companies, such as Cargill, that move water through engineered pond systems to achieve higher and higher salt concentration levels. Habitat quality in salt ponds is determined by water salinity and depth. Low salinity (35-60 ppt) and mid-salinity (60-180 ppt) support a range of fish and invertebrates (especially brine shrimp and brine flies) that are important food sources to resident American avocets (*Recurvirostra americana*) and black-necked stilts (*Himantopus mexicanus*), as well as phalaropes (*Phalaropus* spp.) and many other avian migrants. Benthic invertebrates residing in the ponds are important food sources for shorebirds and many duck species. Very shallow ponds (2-4 inches deep) and ponds between 4 inches and 3 feet deep are especially attractive to birds seeking food in the mud (Goals Project 1999). Islands and insular levees within the ponds provide nesting habitat for a large number of waterbirds including Forster's terns, Caspian terns, California gulls, double-crested cormorants, black skimmers, black-necked stilts, and American avocets.

A.4 Anthropogenic Impacts

In South San Francisco Bay the evolution of tidal flats and wetlands has been dramatically disrupted by human activities. Filling for urban development and diking off of salt ponds has resulted in loss of 29% of the tidal flats, 83% of the tidal marsh, and 98% of the moist grasslands in South Bay since about 1800 (Goals Project 1999).

The primary source of sediment to the San Francisco Bay system is the vast watershed of the Sacramento and San Joaquin Rivers, which comprises 40% of the state of California. During the last 200 years this sediment supply has been significantly altered by human activities. Hydraulic mining during the gold rush introduced massive quantities of sediment into the northern estuary, much of which settled in the shallows of Suisun and San Pablo Bays (Krone 1979). More recently, the widespread construction of dams throughout the watershed, as well as in the tributaries to South San Francisco Bay, has decreased the sediment supply to San Francisco Bay. While these changes in sediment supply impact the northern estuary most directly, they also affect South Bay because suspended sediment from the northern estuary is thought to reach South Bay on an annual basis (Krone 1979). Human activities have impacted the quality as well as quantity of sediments, since many pollutants including refractory organics and heavy metals adsorb to sediment particles. Historic mercury mining in the New Almaden mine in the Guadalupe River watershed is a particularly important source of sediment contamination in the South Bay. Mercury mining began in this region during the Gold Rush, so it is possible that a significant reservoir of mercury-laden sediments is stored within South Bay tidal flats. If this is the case, erosion of mudflats would likely increase the bioavailability of the mercury.

Since the early 1900's, Santa Clara Valley and the southern end of the San Francisco Bay have subsided significantly (an average of approximately 1 m) due to groundwater pumping in Santa Clara Valley. In most of the South Bay, deposition of sediment has largely compensated for the subsidence. However the salt ponds were isolated from natural sources of sediment by dikes, and now have depths up to 1 m greater than the adjacent Bay shallows. As a result, a large volume of sediment is required to bring the salt ponds up to marsh plain elevation.

The continuing urbanization of the region has resulted in the discharge of large volumes of storm water and treated wastewater to the South Bay. Today, the combined municipalities of Sunnyvale, Palo Alto, and San Jose discharge over 150 million gallons per day of treated wastewater south of the Dumbarton Bridge, a region with relatively poor circulation. Before

1950, the discharge of untreated sewage frequently produced anoxic conditions, bacterial contamination, and foul odors in the Bay (Davis et al., 1991). Primary treatment began to improve water quality in the 1950s, although anaerobic conditions occurred episodically in the South Bay through the 1960s. Today, all waste discharged to the Bay receives secondary treatment, and the treatment plants discharging south of the Dumbarton Bridge apply advanced tertiary treatment. As a result, conventional pollutants such as turbidity, biological oxygen demand, and bacteria from the treatment plants no longer impact South Bay water quality. There continues to be concern over the potential for ecological impacts of metals and other contaminants in treated waste, although the discharges to the South Bay typically comply with all discharge standards for toxics. Storm water is another significant source of pollutants to South Bay: on an annual basis it is comparable in magnitude to treated wastewater for some substances. The discharge of treated wastewater has also impacted South Bay ecology by converting salt marsh to freshwater marsh in the region of the San Jose discharge.

Human activities have produced a wide range of chemicals that have found their way to Bay waters and sediments. A number of these chemicals have the potential to cause serious ecological and health problems, impairing Bay ecosystem functioning. Polychlorinated biphenyls (PCBs), lead and other heavy metals, petroleum products, excess nutrients and pesticides are all present in the Bay and some, such as PCBs, make their way into the food chain (Luoma 2000). Of particular concern is mercury, which in the methyl mercury form is bioavailable and accumulates to dangerous concentrations in top trophic level organisms. The return of ponds to salt marsh increases the methylation of mercury (Gill et al. 2002); thus, the Project could increase levels of this pollutant.

Humans have also had a tremendous effect on the Bay's ecology by introducing non-native species. San Francisco Bay is considered the "most invaded aquatic ecosystem in North America" (Cohen and Carlton 1995). We have introduced hundreds of species, either accidentally or on purpose, and some habitats are completely overrun by these invaders. For example, non-native species dominate benthic communities in the Bay. There are more than 200 established non-native species and some of these have become serious management problems (Dudley 2000). Major impacts of invasive species include competition with native species, predation of native species, changes to food webs and alterations to habitat structure and dynamics (Cohen and Carlton 1995). The most serious threats to South Bay habitats come from plants such as *Spartina alterniflora*, *Lepidium latifolium*, and *Arundo donax*, species that invade salt marsh, brackish marsh and freshwater marsh, respectively. Invasive invertebrates, occurring in some parts of the Bay, include the overbite clam, *Potamocorbula amurensis*, mitten crabs (*Eriocheir sinensis*) and green crabs (*Carcinus maenas*). Non-native red foxes are efficient predators of native species, especially species nesting in low vegetation or on the ground. An important challenge facing the Project is controlling non-native species so that they do not compromise ecosystem functioning.

A.5 The Initial Stewardship Plan

The South Bay Salt Pond Restoration Project region includes the majority of the ponds in three former Cargill salt pond complexes: Alviso, Baumberg and Redwood City (also known as West Bay). These ponds are owned by California Department of Fish and Game (CDFG) and the U.S. Fish and Wildlife Service (USFWS). Before operation and maintenance responsibility is transferred to the agencies, Cargill will reduce salinity in the ponds. Some ponds may be transferred in 2004 while others will be transferred later. Following transfer of the ponds and prior to long-term restoration, the agencies will operate the ponds according to the Initial Stewardship Plan (ISP) (subject to permits issued by the Regional Water Quality Control Board) to maintain habitat value in the ponds and keep the ponds in conditions suitable for long-term restoration.

Under salt production operations, salt that was taken into the salt ponds was eventually harvested in crystallizer ponds at the Cargill plant site. During Initial Stewardship, the ponds in the Project area will be disconnected from salt production operations. Therefore, in order to keep water in the ponds and avoid salt buildup, water will be circulated through the ponds and back to the Bay. The ponds in the Project region will be divided into independent pond systems and additional hydraulic infrastructure will be installed, including discharge structures to convey water from the ponds to adjacent tidal sloughs and, ultimately, the Bay. The Initial Stewardship Plan (Life Science 2003b) describes the proposed additions and modifications to hydraulic infrastructure, as well as existing infrastructure. Specific operation of the infrastructure is proposed to control circulation and water levels in the ponds. In several pond systems the operation of the ponds will vary seasonally to provide seasonal habitat in the ponds, to reduce pumping expense, and/or to minimize potential ecological impacts.

Because the ISP proposes to discharge water from the ponds to the Bay, ecological impacts may occur near the discharge locations. For each pond group, two distinct periods of discharge have been identified. During the Initial Release Period (IRP), the water initially in the ponds, which will have elevated salinity relative to bay salinity, will be discharged to the Bay and replaced with bay water. After 1-2 months of discharge, a typical pond system will reach salinity values similar to bay salinity. At that time, the Continuous Circulation Period (CCP) will begin, during which the pond system operates at salinity values similar to bay salinity, with somewhat greater salinity during summer due to high net evaporation in the ponds. Most pond systems are designed to maintain discharge salinity of less than 44 ppt even during summer conditions.

The ISP proposes that the Alviso Complex Island Ponds be opened to tidal action by breaching the levees in selected locations. These ponds are particularly good candidates for restoration to tidal action for three reasons; 1) they are less subsided than most other Alviso Complex ponds; 2) there are a limited number of flood management of infrastructure protection issues associated with the pond; and 3) due to their inaccessibility, it would be difficult to operate them as managed ponds.

A.5.1 Initial Stewardship Plan Studies

Studies conducted as part of the Initial Stewardship planning process included collection of water quality and sediment quality data in the ponds and receiving waters and water quality modeling in the ponds and receiving waters. The potential effects of pond discharges on aquatic life during both the IRP and CCP were estimated based on model predictions.

Conditions in the ponds were predicted using a hydraulic model of the ponds. For each pond group, this model estimated the circulation through the ponds, the salinity in the ponds and the water depths in the ponds during a large range of tidal and weather conditions. The habitat value of a pond is controlled to a large extent by the depth and salinity at which the pond is operated. In many ponds the expected conditions during Initial Stewardship will be different than the conditions in the ponds under salt production operations. Under the ISP, some ponds remain in a similar depth range as historic conditions while others will change, in some cases to deeper operation and, in other cases, to shallower operation. Under the ISP the salinity in many ponds will decrease. This will cause a decrease in area of the "medium salinity" ponds (approximately 100 ppt to 150 ppt) in which brine shrimp and brine flies are prevalent (Life Science 2003b). The overall reduction of pond salinities may impact some avian species (phalaropes and other species) by eliminating foraging in hyper-saline ponds. In ponds with reduced depths, nesting areas may be eliminated by the creation of new land bridges to islands.

The pond discharges may have effects on receiving water quality. For this reason the salinity and flow rate estimated by the pond hydraulic model directly fed into the modeling of the Bay and sloughs. The discharge from the ponds may also influence metals concentrations and dissolved oxygen (DO) concentrations in receiving waters. The effect of pond discharges on receiving waters was estimated using a three-dimensional hydrodynamic model, coupled with field data collection. The simulation effort focused on the slough regions to which the pond systems discharge.

The results of the bay and slough models were analyzed to determine the potential for aquatic impacts. In most discharge locations, predicted receiving water salinity outside of the immediate discharge location remained within the typical ambient range of bay/slough salinity. Some impacts are expected to occur in a limited number of slough locations during the Initial Release Period, primarily due to the high salinity of the water discharged during that period and possibly due to elevated metal concentrations in the ponds. In contrast, during the Continuous Circulation Period, pond salinities are typically similar to bay salinity and aquatic impacts are not expected. There is a potential for depressed DO in pond discharges that could occur even during the CCP due to the diurnal cycle of DO in the ponds that results from photosynthesis and respiration of algae.

The technical study for the ISP included analysis of the effects of breaching the Island Pond levees on hydrodynamics and salinity in Coyote Creek and other adjacent slough regions. Breaching the Alviso Complex Island Ponds is expected to result in significant increases in tidal prism and tidal velocities in adjacent regions of Coyote Creek and increases in local salinity. The magnitude of the hydrodynamic and salinity effects will depend to a large extent on breach geometry and will change in time as the breach geometry evolves. Sediment accretion in the Island Ponds and scour in Coyote Creek are also expected to result from the levee breaches and will affect the tidal hydrodynamics and salinity in Coyote Creek.

Monitoring of ponds, discharges and receiving water is also proposed as part of the discharge permit conditions for the ISP. Salinity, temperature, DO, and pH of the discharges will be routinely monitored at the discharge points and in the receiving waters. Concentrations of metals and sediment, benthos, fish, and invertebrates will be monitored less frequently.

A more complete description of field and analytical data, hydrodynamic and water quality modeling and impact assessment associated with the ISP is provided in the South Bay Salt Ponds Initial Stewardship Plan EIR/EIS (Life Science 2003b).

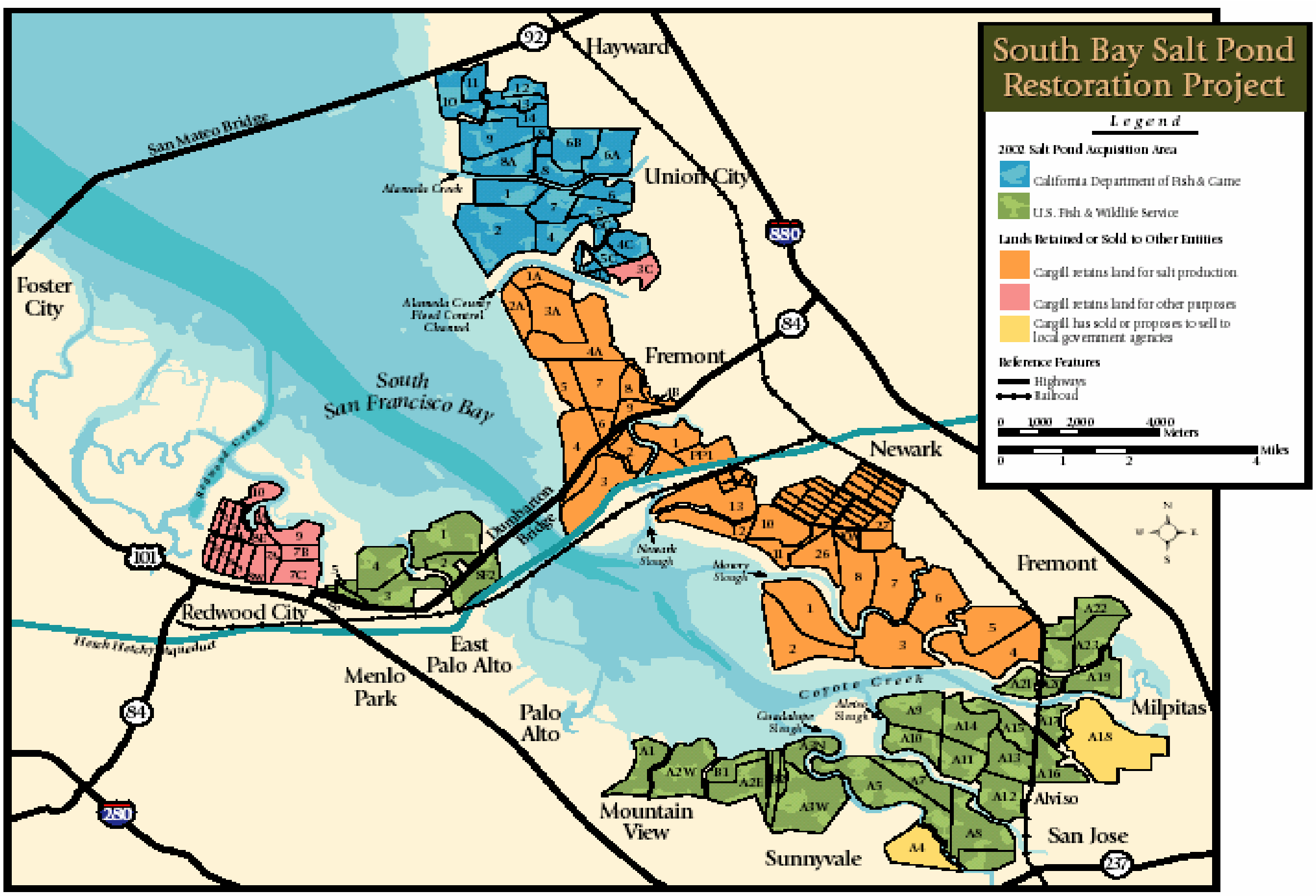
A.5.2 Relationship to South Bay Salt Pond Restoration Project

The Initial Stewardship period could be considered the first phase of the larger South Bay Salt Pond Restoration Project. A major objective of the ISP is to maintain the ponds in conditions suitable for long-term restoration. The ISP will influence Project planning primarily because much of the hydraulic infrastructure used during Initial Stewardship will also be used for managed ponds in the long-term restoration. As long-term restoration proceeds, much of the pond management proposed in the ISP will require modification.

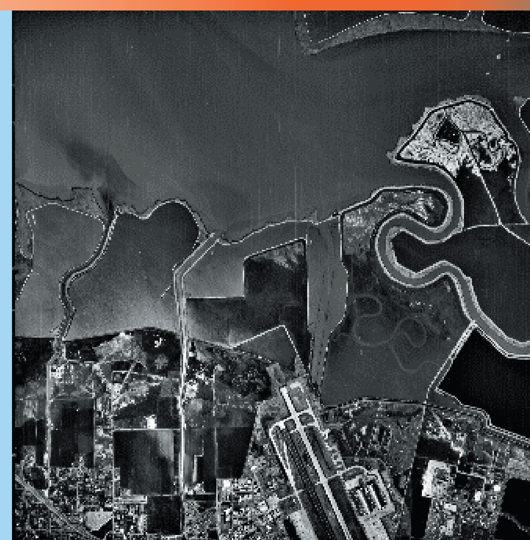
The Alviso Complex Island Ponds could be considered a pilot restoration project for the South Bay Salt Pond Restoration Project, although restoration is predicted to be less complicated for these ponds than for many others. Pond and receiving water monitoring associated with the restoration of these ponds may provide valuable information for planning phased restoration for the Project.

Figure A.1. The South Bay Salt Pond Restoration project Area.

The Project is located south of the San Mateo Bridge in three sets of pond complexes: the Baumberg complex (in blue) just south of the Bridge on the east Bay, the Alviso complex (in green) from Fremont to Mountain View, and the Redwood City or West Bay ponds (in green), clustered around the Dumbarton Bridge.



APPENDIX B - CONCEPTUAL MODELS



APPENDIX B: CONCEPTUAL MODELS

Appendix B.1. LANDSCAPE CONCEPTUAL MODEL

B.1.1 Model Goals and Elements

The Landscape Conceptual Model provides a guide for understanding how restoration actions initiated at the pond level will affect physical and ecological processes in the South Bay and associated sloughs, as well as potential effects of the surrounding landscape on the restored ponds. The elements included in this model are the same as those for the two pond-level models; however, the focus is on effects at the landscape level. The elements are linked in Figure B.1.1 to show relationships between driving processes, restoration actions, and South Bay ecology.

The Landscape Conceptual Model considers effects on two different scales. The larger scale is South San Francisco Bay, defined as the portion of San Francisco Bay that abuts Central Bay "on the western side at Coyote Point, and on the eastern side at the San Leandro Marina" (Goals Project 1999). The largest and most direct effects of the salt pond restoration Project will occur within this region, with smaller effects in the greater San Francisco Bay and beyond. The smaller scale is the "slough scale" consisting of groups of ponds and adjacent sloughs or bay regions.

B.1.2 Driving Forces in South Bay Ecology

The driving forces for restoration that lead to creation of habitat within ponds are discussed in Appendices B.2 and B.3. Many of these driving forces also influence physical processes and ecology on the landscape scale. For example, sedimentation in the ponds will occur by transport of sediment from the bay and sloughs into the ponds. In addition to changes in landscape-level sediment dynamics, restoration may also affect water quality and other physical attributes on a large scale. In terms of nutrients and pollutants, restored ponds may become sinks as both nutrients and pollutants are associated with sediment particles, which will accumulate in restored ponds. Whether restored ponds become pollutant sources will require study; however, there may be some cases, e.g., mercury, where ponds could become important transformers of pollutants that could be made bioavailable. Please note that a distinction is made between driving forces which lead to creation of habitat in ponds, and constraints on restoration, which are discussed in Section B.1.7.

Primary physical driving forces in the South Bay and Sloughs include:

- tidal fluctuation and currents
- fresh water inputs
- sediment concentrations, deposition and erosion
- water quality (including salinity, nutrients and pollutants)
- wind waves
- bathymetry and topography

In addition to these physical processes, there are also habitat issues that are important at the landscape level, as well as feedbacks between biological components and these driving forces. In particular the spatial distribution of habitat resulting from the Project will have important effects on large-scale ecological processes. Issues of concern are:

- the size and shape of habitat patches, including the minimum habitat patches sizes needed to support species of special concern;
- habitat connectivity (including the influence of levee abandonment between restored areas);
- proximity between habitats and other features (e.g., the bay shoreline or developed areas)
- the effects of habitat edge (including the type and quality of adjacent transitional and upland habitats) on habitat value;
- food web support;
- species population dynamics at regional and larger (flyway) scales;
- large-scale patterns of sediment deposition and erosion affecting habitat distribution.

B.1.3 Desired Habitats and Target Conditions

The Tidal Marsh and Managed Pond Conceptual Models focus on achieving desired habitats through restoration and management actions. These habitats are characterized by specific target conditions. At the landscape scale, the entire mosaic of restored, managed and unchanged habitat types should produce conditions that meet the Project's goals. Thus, viewed over the South Bay region, landscape-level target conditions should include:

- a mosaic of wetland, tidal flat, subtidal, managed pond, and transitional upland habitats that supports the existing diversity of species at viable levels and increases populations of rare species;
- maintained or improved flood protection; and
- maintained or improved water quality in the South Bay.

B.1.4 Potential Landscape-Level Effects of Restoration Actions

The South Bay Salt Pond Restoration Project will undertake restoration actions in several phases. These actions will alter driving forces leading to different habitat conditions in the ponds and these changes to the ponds will have effects on the landscape scale as well. Likely changes will include breaching levees and managing water movement into ponds. A range of typical restoration and management actions that may be implemented are listed in Chapter 2.

Large-scale salt pond restoration and management in the South Bay will have effects at the landscape scale. Potential effects include:

- changes in tidal hydrodynamics, including tidal prism and tidal range in tidal sloughs;
- improved flood protection in South Bay tributaries;
- decreased dredging of slough channels for flood protection;
- changes in water quality in adjacent Bay waters and sloughs;
- altered sediment concentration in Bay and sloughs;
- decreased turbidity, making conditions more favorable for phytoplankton blooms;
- increased mercury and/or methyl mercury concentration on a regional level;
- depressed dissolved oxygen near managed pond discharges;
- increased eutrophication;
- increased odor;
- increased population size for endangered species and other species of concern and greater opportunities for movement and breeding between populations;

- increased habitat connectivity for all organisms that use multiple marsh and/or aquatic habitats, including birds, mammals, and fish;
- improved habitat connectivity with adjacent upland habitats;
- loss of existing habitat for native special status species;
- erosion of existing tidal flats;
- loss of hypersaline wetlands and their unique communities;
- reduction in predation for species of concern with larger habitat blocks;
- increased nursery habitat in wetlands for fish;
- increased salmonid entrainment into managed ponds;
- increased overall marsh productivity and export of material for detrital food webs;
- shifts in populations of migratory birds;
- decreased bay shrimp population;
- increased spread of *Spartina alterniflora* and the hybrid*;*
- increased mosquito populations;
- damage to existing infrastructure (roads, bridges, pipelines, power equipment, etc.); and
- increased expense of levee maintenance.

In the following sections, we discuss the effects of the two most important large-scale restoration actions, breaching levees and managing ponds, at the slough and landscape scales.

B.1.5 Breaching Salt Pond Levees

One restoration action that will have considerable effects on both the salt ponds and South San Francisco Bay is breaching pond levees. At the landscape scale, the effects will vary depending on the number of ponds breached in an area, and effects will vary in time as the pond(s) and neighboring tidal sloughs, marshes and tidal flats evolve. Breaching of levees will result in large-scale creation of intertidal wetland habitat; however, there are also potential negative impacts on neighboring habitats and resources. A relatively brief discussion of the expected effects on neighboring sloughs and then on the larger South Bay system resulting from breaching salt pond levees follows.

B.1.5.1 Slough-Scale Effects of Breaching Levees

A relatively direct effect of breaching a pond levee is a change in local tidal hydrodynamics. Breaches allow tidal exchange between the ponds and adjacent bay or slough regions and, therefore, influence the tidal hydrodynamics near the restoration site. For example, seaward of a levee breach on a tidal slough, the following hydrodynamics effects typically occur immediately following the construction of a breach:

- Increased tidal prism
- Increased velocity
- Decreased tidal range

Changes to tidal hydrodynamics may affect sediment dynamics and water quality of the slough, in the following ways:

- Sediment resuspension
- Transport of sediment into ponds
- Scour of the slough channel

- Changes in planform of slough channel, possibly resulting in levee erosion
- Mobilization of contaminants bound to sediment
- Altered (generally increased) salinity

Changes in tidal hydrodynamics in the slough will lead to adjustment of breach and slough channel geometry. In addition the bed elevation in the pond is likely to evolve towards an elevation typical of vegetated tidal marsh plain. In the interim period, the pond may be open water habitat or tidal flat habitat. The rate of accretion in the restored pond will be controlled by the rate of sediment supply from the bay and the efficiency with which this sediment is trapped in the pond. Sediment deposited in the ponds may be resuspended, primarily as a result of wind waves, and transported out of the ponds, slowing the rate of accretion in the ponds. Relatively large velocities in the pond near the breach may erode bottom sediment or the sides of the breach, providing a source of sediment to the pond and the slough. As the pond elevation increases, the tidal prism associated with the pond will decrease, leading to decreased effects on hydrodynamics in the tidal slough. Therefore the expected effects of the restoration project can be classified in several distinct phases. The exact trajectory that each individual project area follows will depend on local conditions and the restoration actions performed. As an example, assuming that the breach geometry and slough geometry evolve rapidly relative to the pond elevation, the following phases may occur:

1) Initial phase – In this phase immediately following construction of the breach, the existing pond elevation and slough geometry are present. Following construction, the breach geometry will evolve, in most cases to a larger breach area. Relatively large velocities in the pond near the breach may erode bottom sediment or the sides of the breach. When the breach area increases the tidal range in the pond may increase and the pond may transition from open water habitat to tidal flat habitat. As a result of the increased breach area, the tidal prism and velocity in the slough channel (seaward of the breach) will increase leading to increased resuspension of sediment in the slough. If the slough channel area is too small to supply the tidal prism required to fill both the pond and slough to high water, the tidal range in the slough will decrease.

2) Adjustment of breach and slough to increased tidal prism – In this phase the breach and slough area have increased to allow full tidal range (maximum tidal prism) inside the restored pond. This adjustment of slough morphology will probably result in loss of tidal flat and fringing marsh habitat in the sloughs. However, tidal flat habitat and, potentially, marsh habitat should be present in the restored pond. The tidal velocity and tidal range in the slough would probably be similar to conditions before construction of the breach.

3) Evolution of pond to tidal marsh – As the pond evolves towards tidal marsh, the tidal prism into the pond will decrease, leading to tidal prism and velocity decreases in the slough. Increased accretion in the slough may lead to formation of new tidal flat and marsh areas.

As a result of this restoration action, several impacts could occur in the slough, including:

- increased risk of flooding;
- mobilization of contaminated sediment;
- increased methyl mercury concentrations;
- loss of existing tidal flat habitat;

- loss of existing fringing marsh habitat;
- loss of bay shrimp habitat; and
- increased levee erosion.

As slough channels and tidal flats erode contaminated sediment could be mobilized. In some locations contaminated sediment buried below cleaner sediment may be mobilized as the bed erodes. This concern is particularly acute in and near Alviso Slough where mercury has entered and continues to enter South San Francisco Bay due to mining activities in the Guadalupe River watershed.

As slough channels erode some tidal flat regions along the tidal sloughs may become subtidal. In addition broader erosion of tidal flats is expected as sediment eroded due to tides and wind waves is trapped in restored ponds.

Similarly, some fringing marsh habitat adjacent to salt pond levees will be impacted by restoration actions. Fringing marsh habitat may be converted to tidal flat particularly in channels connecting sloughs to the restored ponds. More generally, erosion in slough channels due to increased tidal prism may result in conversion of fringing marsh habitat to tidal flat habitat.

Bay shrimp are believed to have salinity preferences that vary during their life cycle. Breaching levees along some sloughs is likely to result in increased salinity in the sloughs. These changes in salinity may decrease the preferred habitat area of bay shrimp (S.R. Hansen & Associates, 2003b).

Levee erosion typically occurs as a result of wind waves. In deeper water with long fetch differences, relatively large waves can develop and results in erosion of levees. Therefore, if the restored ponds, particularly the subsided Alviso Complex ponds, operate at higher water surface elevation (deeper) under restored conditions than current conditions, levee erosion may increase inside the ponds. In addition to the possibility of increased levee erosion in the ponds, levee erosion can increase along the sloughs resulting from erosion of the slough channels or, more generally, changes in planform of the sloughs.

The potential for flooding may also increase as a result of breaching levees. In general it is expected that breaching levees will lead to slough scour and, therefore, increased conveyance in slough channels. While this is true for the reaches of a tidal slough seaward of a breach, the opposite effect may occur landward of a levee breach. Decreased tidal prism is expected landward of newly constructed breaches for some time period following the construction. During this period, the landward (upstream) portions of the slough may accrete, leading to decreased conveyance and potentially increased flood risk. More subtle effects of the restoration could also influence flood risks. These effects include storage in the ponds, and changes in effective resistance to flow due to changes in slough vegetation, bed forms and tidal prism.

Breaching levees should have several ecological benefits. At the slough scale, there are likely to be some positive effects in terms of opportunities for fish movement up channels and into marsh habitats, as well as for movement of other animals and plant propagules. Pond breaches will initially result in open water habitats used by diving birds and shallows used by shorebirds, but diving birds use will soon decrease with accretion of sediments and marsh plain development. Reduction in salinity will result in increased use by fish and likely by piscivorous avian predators. As sloughs deepen and widen, adjacent fringing marsh habitat may be converted to tidal flat habitat or subtidal habitat. Therefore, populations of some tidal marsh species may be reduced initially. Eventually, the area of vegetated tidal marsh habitat will increase substantially, creating a mosaic of ponds and marshes, which should allow increased populations of tidal marsh species. However, the final landscape will be less variable than historic conditions, as flood control levees and adjacent development reduce habitat alteration from natural events such as flooding. Sea-level rise may decrease total tidal marsh habitats if rising waters inundate vegetated plains and waters are captured within protective flood levees.

B.1.5.2 South Bay-Scale Effects of Breaching Levees

In addition to the direct effects on regions neighboring project areas, physical and ecological effects are expected in a significant portion of San Francisco Bay. One of the major positive effects of large-scale breaching of salt ponds will be the creation of new habitat for endangered species and other target species. As salt marshes and brackish marshes evolve in these new areas, they will greatly expand the overall area of wetland habitat in South Bay. This increase in habitat will support a substantial increase in these populations. In addition the newly created habitats will serve as corridors for individuals to move from one region of the South Bay to another. Existing marshes in the south bay are found in isolated areas surrounded by expanses of salt ponds. With restoration of large tracts of salt ponds, it will be possible for clapper rail to more easily move from one marsh to another. Similar effects are likely for other species of concern.

Beyond endangered species, there also will be increased connections between existing habitats for all species that use South Bay wetlands, including fish, mammals and birds. The effects that are discussed above under slough scale are likely to be even greater at the Bay scale.

One of the major negative effects expected following breaching of salt pond levees is erosion of South San Francisco Bay tidal flats. Currently some South Bay tidal flats are believed to be accreting, particularly in portions of Coyote Creek near the Alviso Complex while other tidal flat regions are believed to be eroding. When ponds are restored to tidal action they will act as sediment sinks because some of the sediment periodically resuspended from the tidal flats due to tidal currents and wind waves will be trapped in the ponds. If the rate of sediment accretion in the ponds exceeds the sediment supplied to South Bay from local tributaries, and sediment that enters South Bay via Central Bay, South Bay would become net erosional and it is likely that existing tidal flat habitat will be lost. However, it should also be noted that new tidal flat habitat will be created in several ponds as they evolve towards vegetated tidal marsh. The tidal flat area in South Bay proper and within the Project area will evolve in time as a result of restoration actions and net loss of tidal flat area may be a transient or permanent result of restoration actions.

Because the breached salt ponds will act as sediment sinks, restoration may lead to decreased suspended sediment concentrations and decreased turbidity in South Bay. This could make conditions more favorable for phytoplankton blooms (Shellenbarger et al. 2004).

Several additional factors should be considered when considering the evolution of South San Francisco Bay morphology and habitats following restoration of ponds to tidal action. Additional factors discussed by Orr et al. (2003) are sea-level rise, sediment supply from tributaries, and local subsidence. Furthermore, restoration projects may change the tidal range in portions of South San Francisco Bay with the most pronounced effects in tidal sloughs bordering restored ponds.

On the landscape scale, the following impacts are likely due to breaching salt pond levees:

- increased methyl mercury concentrations;
- mobilization of contaminated sediment buried at depth;
- loss of existing tidal flat habitat;
- loss of pond habitat; and
- local loss of existing fringing marsh habitat.

These potential South Bay scale impacts are similar to potential slough scale impacts discussed in Section B.1.5.1, but at a larger scale.

B.1.6 Operation of Managed Ponds

Managed ponds provide valuable habitat for native special status species, other native species, and migratory bird species. The habitat value of managed ponds is discussed more thoroughly in the Managed Pond Conceptual Model in Appendix B.3. The operation of managed ponds to maximize resource value is discussed in Section B.3.5. Pond attributes that can be managed include circulation, pond depth, salinity and the presence of habitat features, such as islands.

B.1.6.1 Slough-Scale Effects of Managed Pond Operation

There is considerable uncertainty about the potential effects of managed pond operation on the slough and landscape levels. However, several effects managed pond operation may have on the slough scale compared to current conditions include:

- depressed dissolved oxygen near managed pond discharges;
- increased or decreased eutrophication;
- increased or decreased odor;
- increased salmonid entrainment into managed ponds;
- increased or decreased mosquito populations; and
- increased expense of levee maintenance.

Many effects of managed ponds on local ecology will be related to the circulation of water through the ponds. In most locations water will be brought into the ponds “by gravity,” meaning that inflows will enter ponds via culverts without the use of pumps. This inflow will occur near high water when the water elevation in the bay is higher than the water elevation in the intake pond. The inflow volume can be controlled to a large extent by the operation of waterman gates (“screw gates”) that limit the flow through each culvert. Under the Initial Stewardship Plan the daily intake volume at each intake location will typically be 2% to 5% of the water volume contained in the pond group. Therefore the depths in most ponds will not vary substantially over the tidal cycle. However, the depth in some ponds will vary over the fortnightly spring-neap cycle with more inflow and deeper operation typical during spring tides. Furthermore pond depth may also increase temporarily due to rainfall.

The intakes will bring bay water into the ponds and all material that is dissolved and suspended in bay water. This dissolved and suspended material includes salt, sediment, nutrients, contaminants, phytoplankton and fish. Existing intakes and intakes proposed for the Initial Stewardship Plan generally contain “trash racks” to screen large debris but do not contain fish screens. Therefore one concern at the intake points is the possibility of salmonid entrainment, particularly during the downstream migration of juvenile salmonids. The potential for entrainment of salmonids can be minimized by closing intake gates located in migration corridors during salmonid migration periods, as is proposed for the Initial Stewardship Plan (S.R. Hansen & Associates, 2003c).

Some effects are expected near discharge locations of managed ponds. Many pond discharges in the Initial Stewardship Plan and Project will be located in tidal sloughs. The discharge volumes from the ponds during a tidal cycle are typically two to three orders of magnitude smaller than tidal prism in the sloughs. The discharges typically occur by gravity flow (without pumps) near low water including low slack water when tidal currents are weak, and both water volume and salinity are at a tidal cycle minimum. Increases in salinity are likely near the discharge point during slack water but the largest increases are expected to be transient and to occur in a small zone near the discharge points. Salinity effects will decrease with distance from the discharge as the pond water mixes with ambient water. Relatively small salinity increases are expected near high water because the large volume of water that enters during a flood tide will mix with the pond water. Because pond discharges will occur near low water, the discharged water will be displaced landward by the following flood tide, increasing the residence time of the water in the sloughs.

The degree of mixing of pond discharges with ambient water may be reduced if stratified conditions are present. Elevated salinity pond discharges may cause stratified conditions and potentially larger salinity effects near the bed of a slough channel than the overlying water column. Stratified conditions are more likely in sloughs with low salinity, such as Artesian Slough, and during periods with relatively weak (neap) tides.

These salinity increases may change habitat conditions near the discharge points leading to changes in vegetation type and, potentially, impacts on benthic organisms (S.R. Hansen & Associates, 2003d). Because bay shrimp are believed to have salinity preferences, changes in salinity may also change the preferred habitat area of bay shrimp (S.R. Hansen & Associates, 2003b).

Other water quality effects may occur near discharge points. The concentration of dissolved substances in pond water typically increases as water evaporates from the ponds. Although metals do not behave conservatively in the ponds, observed metal concentrations in salt ponds do generally increase with increased pond salinity (S.R. Hansen & Associates, 2003a). Therefore salt pond discharges may have elevated metal concentrations relative to receiving water concentrations. Increases in metal concentrations could impact aquatic life near discharge points. The metals of particular concern are nickel and mercury.

Dissolved oxygen (DO) concentration in the ponds is observed to follow a diurnal cycle (S.R. Hansen & Associates, 2003e). Due to photosynthesis during the day, DO concentrations in the ponds are typically saturated or super-saturated. However, due to algal respiration during the night and morning, observed DO concentrations can drop below 5 mg/l (S.R. Hansen & Associates, 2003e). A similar diurnal cycle has been noted in the sloughs (Kinnetic Laboratories Inc. and Larry Walker Associates 1987). If the DO concentration in a pond discharge is lower than the DO level in the receiving water during the night or morning hours, discharges may lead to decreased DO in the receiving water.

In addition to affects on bay ecology and water quality, pond management may have effects on humans. Potential impacts on humans include increased flood risk, odor and mosquitoes. Levee erosion typically occurs as a result of wind waves. In deeper water with long fetch differences, relatively large waves can develop and result in erosion of levees. Therefore, if the restored ponds, particularly the subsided Alviso Complex ponds, operate at higher water surface elevation (deeper) under restored conditions than current conditions, the rate of levee erosion may increase inside the ponds increasing the risk of levee overtopping and failure. Managed ponds can also create odor due to algal decomposition. Odor typically occurs when ponds have recently dried out and during warm summer conditions. Another potential direct impact to humans is increased mosquito population resulting from changes in pond management.

B.1.6.2 South Bay-Scale Effects of Managed Pond Operation

Managed pond operation may have several effects on the South Bay scale, including:

- changes in water quality in adjacent Bay waters and sloughs;
- increased mercury and/or methyl mercury concentration on a regional level;
- loss or gain of existing habitat for native special status species;
- support of hypersaline wetlands and their unique communities;
- shifts in populations of migratory birds;
- decreased bay shrimp population;
- change in disease transmission.

Managed ponds provide critical roosting habitats during high tides when mud flats are inundated. Managed ponds provide a favorable microclimate, especially during winter storms; levees offer protection from winds, and islands or cut levees isolated by deeper water provide protection from mammalian predators. A landscape with too few managed ponds may result in high levels of disease, disturbance, and predation in those ponds. Predation may result in mortality of a large number of individuals in shorebird and nesting colonial waterbird species. Managed ponds also provide foraging resources, as up to 50% of the birds in the salt ponds are feeding (Warnock et al. 2002). These protected habitats may be critical for migratory birds during winter storms when birds are unable to forage on mud flats.

One key difference between the proposed Initial Stewardship period operation and the historic operation is that many ponds will operate at lower salinity leading to loss of medium and high salinity pond habitat. However, outside the project area, several ponds that Cargill will continue to operate will provide medium and high salinity habitat. In addition to changes in salinity, the depth of operation of many ponds will be different under future conditions than under historic operation. Therefore both the total habitat area of different types of managed pond habitat, and the spatial distribution of this habitat, will be different under future conditions than historic conditions. Some changes in pond salinity and depth are occurring in advance of the Initial Stewardship period as Cargill moves high salinity brines out of the Project area and towards their plant site. These changes in pond salinity and depth will affect the habitat value of the ponds and their usage by birds.

Under the Initial Stewardship Plan and Project conditions several ponds will be operated as seasonal ponds in order to reduce pumping expense and provide salt pan habitat for species including snowy plover. Furthermore bay water may be circulated through some ponds during part of the year (typically winter) while the ponds are drawn down and operated as salt pan during part of the year (typically summer). These changes from current salt production operations should lead to increased salt pan habitat.

Managed ponds may also affect nutrient cycling. The ponds may affect nutrient cycling by importing nutrients and phytoplankton at the intakes and circulated them back to the bay at discharge locations. It is not clear if the ponds will act as a net source or sink of nutrients and phytoplankton.

B.1.7 Constraints on Restoration Actions

The Tidal Marsh Habitat Conceptual Model (Appendix B.2) and the Managed Pond Conceptual Model (Appendix B.3) include discussion of a number of constraints that may limit our ability to achieve desired target conditions in the restoration areas. On the landscape scale, several additional constraints may limit the ability to achieve the desired target conditions (Table B.1.1). Regulatory and economic constraints are not considered.

Table B.1.1. Landscape conditions that significantly constrain restoration outcomes.

Landscape Condition	Potential Constraints
Sediment supply from tributaries	Limits rate of accretion in ponds
Sea-level rise, subsidence	Increases sedimentation required for restored pond bed elevations to reach MHW and become vegetated
Contaminated sediment in bay and sloughs	Limits development and function of restored habitats
Presence of invasive species	Limits development of native plant and animal species in restored areas
Tidal range	Limits ability to operate managed ponds without use of pumps
Highly fragmented habitats	Limits ability of rare species to recover to a viable population level

B.1.8. Adaptive Management
Monitoring appropriate parameters to assess progress toward target conditions and to track negative impacts will be an essential part of the Project. When monitoring indicates changes are needed, adaptive management measures may be taken to correct problems that are developing. The measures taken will depend on the nature of the issue being addressed. Potential issues and adaptive management measures at the pond scale are discussed in Section B.2.8 and B.3.8. Some landscape scale issues that may arise in Project implementation and potential adaptive management measures to address those issues are:

Issue to Address	Adaptive Management Measure
Tidal flat erosion	Delay additional breached levee tidal marsh restoration
Loss of hypersaline wetlands and their unique communities	Change managed pond operation in a subset of managed ponds to create hypersaline habitat
Decreased population of shorebird and/or waterfowl species	Change managed pond operation to increase area of desired habitat
Increased methyl mercury production or presence in food web on landscape scale	Locate new restoration projects in ponds with low Hg levels or change operation of managed ponds
Invasive species	Implement a species control program
Depressed dissolved oxygen near managed pond discharges	Install aerators, or limit discharge during night and morning hours
Loss of existing habitat for native special status species	Choose new restoration sites carefully to minimize additional disturbance or install managed pond infrastructure in less sensitive regions

B.1.9. Topics of Greatest Uncertainty
Conceptual models should aid in identifying cause-and-effects linkages of greatest uncertainty. Given that the conceptual models are still in draft form, identifying these weak links is premature. However, obvious areas of uncertainty at the landscape scale can be divided into short-term and long-term questions, as identified in Chapter 3. For example, some short-term uncertainties include questions about the degree to which mercury and other pollutants may become biologically available due to restoration actions, and the effects of those newly bioavailable pollutants on the food chain. Our ability to control *Spartina alterniflora* and the hybrid, as well as the unknown impacts of this species, leads to uncertainties regarding the floristic composition and functioning of restored wetlands. Long-term uncertainties, whose risks to habitat functioning are very difficult to estimate, include sea-level rise, sediment supply to the South Bay, the introduction of new non-native invasive species, changes to remaining salt pond operations, and the introduction of new pollutants to the ecosystem.

Figure B.1.1. Flowchart of Landscape Conceptual Model.

This graphic shows the major components of a restoration model and the effects on the landscape and slough scales. The arrows do not specify cause-and-effect linkages but, rather, the direction of the effect on the system. Submodels for parts of the system should be developed to show direct linkages between processes and specific target or resultant conditions.

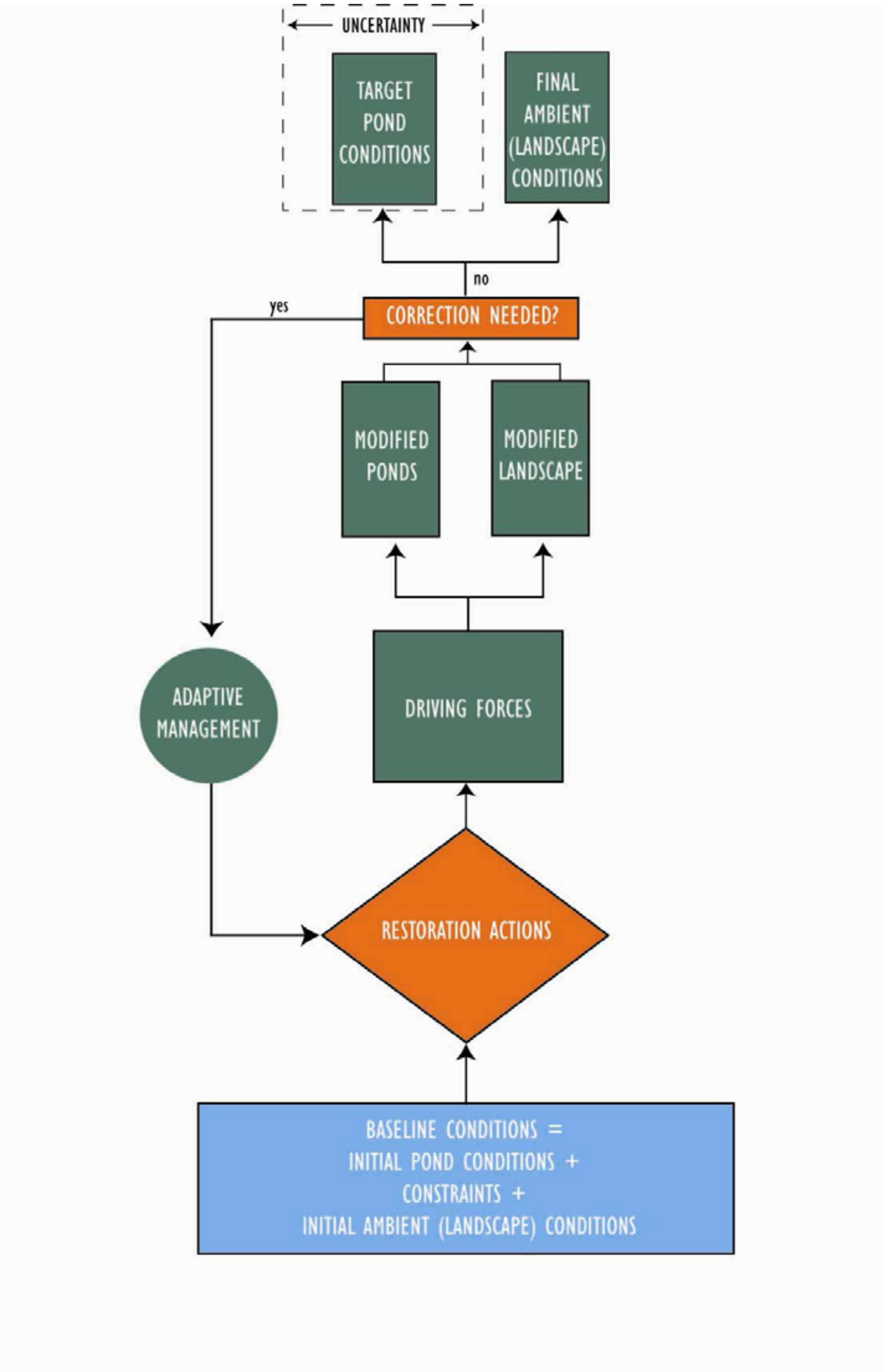


Figure B.1.1. Flowchart of Landscape Conceptual Model

APPENDIX B: CONCEPTUAL MODELS

Appendix B.2. TIDAL MARSH CONCEPTUAL MODEL

B.2.1 Model Goals and Elements

The purpose of this pond-level conceptual model is to provide a guide for understanding how restoration actions can alter current conditions in South Bay salt ponds to achieve vegetated tidal marsh habitat. Descriptive text and a flowchart (Figure B.2.1) are used to show the connections between initial ecological conditions, restoration actions and target conditions (Gross, 2003). Two important caveats of this model are that:

1. this model (as well as the others presented here) are early drafts and are expect to evolve throughout the restoration planning and implementation process, and
2. the model describes only general connections between the model elements. Detailed submodels that illustrate relevant processes will need to be produced in the future to show the specific cause-and-effect relationships between the components (Gross 2003) that lead to tidal marsh and associated habitats. Detailed modeling will provide greater information on natural functions, identify important data gaps, and model the outcomes of different restoration actions.

The model includes these components:

- **driving forces**, the vital processes and structures that shape ecosystem development and maintain them in the long term,
- **restoration actions**, management actions taken as part of the restoration project that alter the driving forces,
- **desired habitats and target conditions**, desired tidal marsh habitats and conditions that are characteristic of those habitats,
- **constraints**, factors that reduce our ability to reach restoration target conditions,
- **baseline conditions**, ecological, physical and structural conditions in ponds and at the landscape scale (bay, sloughs, mudflats outside the ponds) immediately before restoration actions are initiated,
- **potential impacts**, negative effects on ecological conditions or humans resulting from restoration actions or the development of tidal salt marsh, and
- **adaptive management**, monitoring and subsequent actions taken to rectify problems with or impacts of the restoration.

The text for this model discusses each of these components, except for initial pond and landscape conditions. Appendix A briefly summarizes these conditions.

While this conceptual model describes actions and processes at the pond-level scale, the ponds are part of a much larger system, as described in the Landscape Conceptual Model. The Tidal Marsh model shows some general connections to the Landscape and Slough levels, but more work needs to be done to link the models in a substantive way.

B.2.2 Driving Forces: The Key Processes of Change

Driving forces are the key processes responsible for conditions that produce tidal marsh and related habitats. They must be altered or initiated in salt ponds, using appropriate restoration actions, for desired habitats to develop. The primary forces that promote the restoration of tidal marsh habitats (Josselyn 1983) are:

- **Tidal exchange**, measured by variations in water height, duration of inundation, velocity;
- **Water quality**, measured by salinity, DO, temperature, clarity, etc.;
- **Sedimentation**, measured by suspended sediment concentration or flux, rate of deposition;
- **Sediment quality**, measured by particle size, chemical composition (especially toxics);
- **Species traits/dynamics,** measured by proximity of species, dispersal ability, abundance, diversity, and productivity of key marsh species.

These processes are a result of both internal pond conditions and landscape conditions. For example, water clarity in a pond undergoing restoration results from resuspension of sediments within a pond due to wind-driven mixing, as well as from sediments suspended in South Bay water entering the pond.

Before considering Restoration Actions, it may be helpful to understand a little about the ecology of the Desired Habitats and Target Conditions we are seeking through restoration.

B.2.3 Desired Habitats

Desired habitats are the expected goals of pond-level restoration. Tidal marsh and associated habitats, modified from the Goals Project (1999), are:

<u>Baylands</u>

Tidal

- Tidal flat (also known as mudflat)
- Tidal marsh (including vegetated marsh, sloughs, ponds, pannes, and high marsh/upland transitional habitat)
  - Salt marsh
  - Brackish marsh
  - Tidal freshwater marsh

Diked / Non-Tidal

- Non-tidal freshwater marsh
- Managed (muted tidal) marsh
- Shallow saline pond
- Managed (muted tidal) pond

<u>Adjacent Habitats</u>

Riparian forest

Willow grove

Grasslands

- Perennial and annual grassland
- Moist-grassland
- Grassland/vernal pool complex

Coyote scrub

In the South Bay, tidal flat, tidal salt marsh and tidal brackish marsh are the dominant habitats. Unvegetated tidal flats form below MTL where tidal scour and wave action prevent the accretion of sediment to higher levels. The rich benthic community in these flats attracts thousands of migratory birds.

Tidal salt marsh and tidal brackish marsh develop at different elevations and locations in the landscape, and depend on different salinity regimes. These marshes typically exhibit three habitat zones based on the amount of time, depth of inundation, and soil salinity (Goals Project 1999). Low marsh habitats occur from approximately MTL to MHW and experience the greatest amount of inundation daily. They are characterized by unvegetated tidal flat, channels and sloughs, as well as channels and tidal flat vegetated by plants, such as cordgrass in salt marsh and *Scirpus* sp. in brackish marsh, that survive extreme amounts of inundation. The mid-marsh, existing from approximately MHW to MHHW, is inundated twice daily and supports fully vegetated tidal flat. Pickleweed is dominant in salt marsh, but species also include cordgrass, salt grass (*Distichlis spicata*), marsh gum plant (*Grindelia stricta*) and *Jaumea*. Mid-elevations of brackish marsh support bulrushes (*Scirpus* sp.), cattails *(Typha* sp.), *Juncus* sp., and salt grass. The high marsh occurs above approximately MHHW and is inundated only at highest tides. At this elevation, salt marsh species are diverse, including pickleweed, salt grass, fathen (*Atriplex*) and alkali heath (*Frankenia grandiflora*).

At the highest reach of the tide, marsh grades into wetland transitional habitats, such as moist grassland or grassland/vernal pool complexes—which are now quite rare--or becomes upland habitat such native or non-native grasslands. Moist grasslands, typified by perennial bunchgrasses, sedges and rushes, support a wide range of birds, mammals, reptiles and amphibians. Vernal pool complexes are very rare in the South Bay and are known for the endemic species they support, such as the wildflower *Downingia*. A number of rare species are associated with this habitat (fairy shrimp, tadpole shrimp, tiger salamander). Non-native grasslands are the habitats most likely to abut marshes. The great range of non-native species may be supplemented by coyote bush and native bunchgrasses.

In relatively rare instances, freshwater marshes may form, if salinity levels permit. Willow groves and riparian species may be associated with freshwater marshes.

These brief community descriptions focus primarily on the mature community. However, as sites recover from a disturbance, they change over time. Understanding the successionary trajectories of sites is essential to evaluating whether restoration sites are moving in the direction of desired habitats. For example, a simple tidal salt marsh trajectory is:

Open Water Pond + Tidal action initiated + Sediment deposition => Subtidal flats form =>

Intertidal flats form => Pioneer vegetation colonizes => Mature marshplain vegetation + High marsh vegetation

As the elevation of the sediment builds up, the plant community changes, as does the animal community. However, different components of the habitat change at different time scales. Thus, some target conditions, such as tidal prism levels and changes in water quality, are expected to occur almost immediately after appropriate restoration actions are implemented (Simenstad 2000; Williams and Orr 2002). Plant colonization takes longer. In their study of 15 sites in the San Francisco Bay, Williams and Orr (2002) found that 50% plant coverage by native species was achieved between 4 and 20 years after restoration was initiated, depending on the range of tidal fluctuation and initial site elevation. Other target conditions--dominance of the marsh plain by native plants or persistence of breeding clapper rails—will take years, perhaps decades, to establish or may never develop (Zedler 1996). Fully functioning South Bay tidal marshes with mature nutrient levels and cycling processes may not occur for many decades.

B.2.4 Target Conditions: Performance Standards for Monitoring

For tidal marsh restoration to be successful, the restoration actions implemented must—in light of the constraints, initial pond conditions, and initial landscape conditions--produce structures and processes that are typical of vegetated tidal marsh habitats. Typical conditions that characterize South San Francisco Bay tidal marshes include the following:

- **Tidal range** within the marsh must vary enough to result in sediment deposition and to provide the length of daily inundation required by native marsh species. For example, to establish and thrive in salt marsh, native cordgrass (*Spartina foliosa*) requires low marsh elevations with very long daily inundation periods.
- The **marsh plain elevation** is a critical factor in marsh development. It is controlled by the *bathymetry* of the wetland, the amount of *tidal exchange* and the *sediment load* in tidal waters. In a fully tidal marsh, the marsh plain equalizes at approximately MHW, allowing native vegetation to establish. In tidal marshes with muted tidal fluctuation, the marsh plain will stabilize at a different level that balances sedimentation and tidal fluctuation.
- **Adequate channel development** of sinuous, dendritic channels is essential to maintain tidal prism and flow capacity throughout the marsh. Channels of different sizes (1^{st}, 2^{nd}, 3^{rd} order) provide habitat for a range of species, especially the endangered California clapper rail (*Rallus longirostris obsoletus*). Channel formation is controlled by the existing *channel configuration*, *sediment texture*, and *tidal flow velocities*.
- **Water quality**, especially salinity, dissolved oxygen, temperature and clarity, strongly influence the species present. Dissolved oxygen levels vary with tidal movement and mixing. Dissolved oxygen concentrations of 5 mg/l support most aquatic life.
- **Sediment quality** also has a major impact on the species present and their health. Typical tidal marsh sediment salinities of up to approximately 35 ppt and textures of approximately 60% clays and silts (by weight) support most native vegetation. Species will vary depending on sediment conditions. Sediment organic content in mature tidal marshes is approximately 10-20%.
- **Phytoplankton, algae and other vegetation** are critical to providing habitat for animals as well as building nutrient levels and primary productivity. The plant species present are controlled by *marsh elevation*, *tidal flow* (inundation times), *soil and water salinities and nutrient levels*, *species proximity* to the marsh, and *species dispersal ability*.
- **Animal species** are often indicators of ecosystem functioning. Species diversity and rare species are typical indicators of marsh health. The animal species present are controlled by the *vegetation species types, density and maturity*, the *availability of prey or forage*, the level of *predation*, degree of *disturbance*, *species proximity* to the marsh, and *species dispersal ability*. Important organisms include:

  - Benthic species, such as polychaete worms;
  - Epibenthic species, such as native crabs and snails;
  - Fish species, especially topsmelt (*Atherinops affinis*) and goby species;
  - Bird species, especially clapper rails, marsh hawks, duck and shorebird species;
  - Mammals, especially salt marsh harvest mice and harbor seals.
- Each pond that will undergo restoration exists in a regional setting that directly affects the pond's ecological trajectory. **Landscape-level factors** that must be considered in restoration planning include land uses adjacent to planned restoration site, the location and type of pollutant sources, proximity to healthy tidal marsh habitat that could serve as a source of native species, and proximity to non-native invasive species.

The Society of Wetland Scientists (2003) recommends that restoration planning documents clearly state science-based performance standards that are indicators of habitat structure and function. These performance standards 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". For tidal marshes and associated habitats, performance standards must be based on the specific habitat and include a natural range of variability. For some typical parameters and general performance "goals" that could lead to quantitative performance standards see Table B.2.1.

Table B.2.1. General Performance Goals for Three Tidal Marsh or Associated Habitats

Parameter	***Habitat Type with Performance Standards***		
	Tidal Salt Marsh	*Tidal Brackish Marsh*	*Moist Grassland*
Substrate Elevation	MTL-MHHW	MTL-MHHW	MHHW +
Water Salinity	25-35 ppt	10-25 ppt	0 – 5 ppt
Dominant Species	Pacific cordgrass = 80%+ cover at MTL	*Scirpus* sp. = 80%+ cover at MTL	Native bunchgrass = 60% cover; ponds = 20% cover
Rare/Indicator Species	CA Clapper Rail at sustainable numbers	Mixed heron & egret breeding colony	California tiger salamanders breeding
Non-native species	Smooth cordgrass = 0 colonize of non-hybird	*Lepidium latifolium* = <10% cover	Non-native grasses = <25%

B.2.5 Restoration Actions: Initiating Driving Forces

To move salt ponds from their initial conditions along a successionary trajectory toward tidal marsh/associated habitats requires initiating or altering driving forces. The Project will use a range of restoration actions to achieve this. Typical restoration actions and the driving forces they alter are listed in Table B.2.2.

Successful restoration actions are linked causally with specific driving forces, shown in the flowchart for this model (See Figure B.2.1). For example, initiating tidal action in a pond by breaching the pond's levee can result in sediment accretion if the sediment load is adequate, given the depth of the pond. Assuming sufficient sediment exists, the pond bottom elevation will increase, eventually to the point when cordgrass can colonize. The vegetation will help capture more sediment and will further build the marsh plan with dead plant material. Thus, restoring a vegetated salt marsh requires raising the elevation of a salt pond to the level at which native vegetation can invade.

Table B.2.2. Restoration Actions and the Driving Forces they Alter

Restoration Actions	***Driving Forces Altered***
Breaching salt pond levees (including number and locations of breaches)	Tidal prism, water quality, sedimentation, sediment quality, species traits/dynamics
Installing culverts (including size, number, and locations)	Tidal prism, water quality, sedimentation, sediment quality, species traits/dynamics
Depositing dredge materials	Sedimentation, sediment quality
Managing freshwater inflow to ponds	Tidal prism, species traits/dynamics, water quality, species traits/dynamics
Creating channels in marsh plain	
Dredging excess/toxic sediments	Tidal prism, sedimentation, sediment quality
Controlling *Spartina alterniflora* and other non-native species (cats, red foxes)	Species traits/dynamics
Planting/relocating key marsh species	Species traits/dynamics

B.2.6 Constraints on Vegetated Tidal Salt Marsh Restoration

Our ability to reinstate the driving forces that promote marsh formation is likely to be constrained by a number of factors in the South Bay. For example, achieving full tidal exchange may be constrained by existing levee heights (to maintain protection from flooding), existing infrastructure, and adjacent land uses. Other tidal marsh target conditions and their potential constraints include:

Tidal Marsh Target Conditions	**Potential Constraints on the Features**
Marsh plain built to MHW	Current tidal water sediment load, existing pond bathymetry, wave action
Dendritic Channel Development	Sediment texture too coarse, borrow ditches
Native Plant Species Dominate	Sediment too course, sediment toxics, lack of connectivity to plant material sources, non-native species competition
Sustainable Animal Populations	Toxic sediments (Hg issue), lack of connectivity to existing populations, competition/predation by non-native species, inability to provide all habitat needs (for example, upland refugia)
Uncertainties that may affect many Target Conditions	Sea-level rise, impacts of Hg on species, effects of non-native species new to the system after restoration is initiated

This list of constraints focuses on physical and ecological constraints. It is not complete as other classes of factors must be considered, including economic, regulatory, public interest and technology constraints.

B.2.7 Potential Impacts

No pond exists as an isolated system. Each is part of a larger pond system, which is integrated into the South San Francisco Bay landscape. As such, each pond is affected by and affects landscape conditions and processes (see the Landscape Conceptual Model).

Although the goal of the Project is habitat improvement, there is the potential that the restoration of ponds from their initial conditions to tidal salt marsh will have negative impacts within the restored ponds. Some of these impacts might be:

1. <u>Mercury (Hg) methylation in pond sediments, which could effect the food chain.</u>

Enhanced production of methyl mercury, for example, poses a significant threat in both managed ponds and new tidal wetlands. Runoff from the inactive New Almaden mine in the Guadalupe River watershed is a significant source of mercury to South Bay (Davis et al. 2003). Siegel and Bachand (2002) have reported that most contaminants, including mercury, occur in the present salt ponds in concentrations lower than found in the surrounding marsh and slough sediments, presumably because of the passage of many decades since the ponds have been exposed to tidal action and the input of contaminated sediments. This situation suggests that opening ponds to tidal action will result in increased concentrations of mercury within the new wetlands because of (a) direct exposure to Hg-contaminated water and sediments from the Guadalupe River watershed, and (b) exposure to Hg-contaminated sediments that are eroded from adjacent tidal sloughs and mudflats following breaching of salt pond levees. While much remains to be learned about the processes and rates involved, it appears that tidal wetlands tend to trap particulate mercury, and that the presence of high levels of sulfate-reducing-bacteria activity in the organic-rich, anaerobic environments of tidal wetlands suggest that they may be important sites of methylmercury production (Davis et al. 2003). Regular inundation of managed ponds may tend to have the same effect, but perhaps at a much-reduced level.

2. Smells from decomposing algae in the late summer.
3. Fewer shorebirds and waterfowl.
4. Increased mosquitoes.

B.2.8 Adaptive Management for Tidal Marsh Restoration

Monitoring appropriate parameters, such as performance standards, to assess progress toward target conditions and to track negative impacts will be an essential part of tidal marsh restoration. When monitoring indicates changes are needed, adaptive management measures may be taken to correct problems that are developing. The measures taken will depend on the nature of the issue being addressed. Some typical problems that arise in tidal marsh restoration and potential adaptive management measures to address those issues are listed here:

Issue to Address	Adaptive Management Measure
Not enough tidal exchange	Enlarge breaches or add culverts
Not enough sediment to bring marsh plain to equilibrium	Deposit dredge materials to raise marsh plain; Construct wind breaks to increase sediment trapping
Salt pond bird species require roosting and nesting habitat	Build roosting islands or prevent human access to levees and enhance for roosting and nesting
Slow native vegetation establishment	Grow and plant appropriate species
Mercury methylation	Locate new restoration projects in ponds with low Hg levels
Invasive species	Implement a species control program

B.2.9 Areas of Greatest Uncertainty

Conceptual models should aid in identifying cause-and-effects linkages of greatest uncertainty. Given that this conceptual model is still in draft form and specific submodels have not been developed, identifying these weak links is premature. However, some obvious areas of uncertainty, as identified in Chapter 3, can be divided into short-term and long-term questions. For example, some short-term uncertainties include questions about the degree to which mercury and other pollutants will be made bioavailable by restoration actions and the effects of those newly-bioavailable pollutants on the food chain. Our ability to control *Spartina alterniflora* and the unknown impacts of that species make uncertain the degree to which we can restore the composition and functioning of the natural system. Long-term uncertainties, whose risks to habitat functioning are very difficult to estimate, include sea-level rise, the introduction of new non-native invasive species, changes to remaining salt pond operations, sediment supply and geomorphic trajectories of breached ponds and tidal flats, and the introduction of new pollutants to the ecosystem.

Figure B.2.1 Flowchart for the Tidal Marsh Conceptual Model

This flowchart gives examples for each of the model components defining the process of restoring tidal marsh habitats from salt ponds. The general relationship between restoration actions, baseline conditions and effects is indicated. Specific cause-and-effects linkages between elements are not shown; these linkages should be developed in submodels of specific processes.

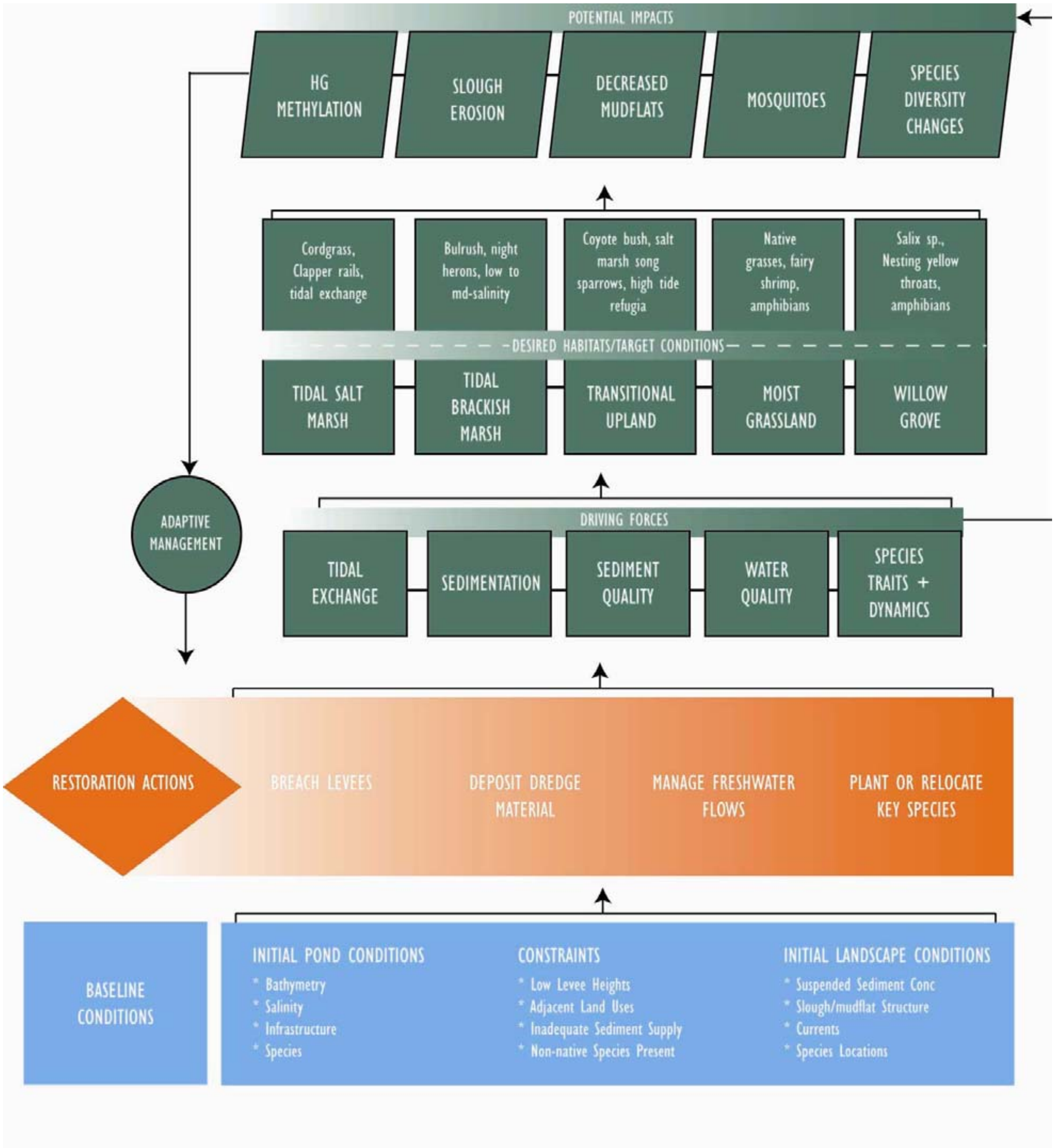


Figure B.2.1. Flowchart for the Tidal Marsh Conceptual Model

APPENDIX B: CONCEPTUAL MODELS

Appendix B.3. MANAGED POND CONCEPTUAL MODEL

B.3.1 Introduction
The purpose of this pond-level conceptual model is to provide a guide for understanding how management actions can maintain and improve managed pond habitat and what effects may be associated with pond discharges. The model includes these components:

- **driving forces**, the vital processes and structures that are altered or initiated by *restoration actions* in the salt ponds, which produce the *target conditions* that characterize functional managed pond habitat,
- **restoration actions**, management actions taken as part of the restoration project that alter the *driving forces*,
- **target conditions**, desired conditions that are characteristic of managed pond habitat,
- **constraints**, factors that reduce our ability to reach restoration *target conditions*,
- **baseline conditions**, ecological, physical and structural conditions extant in ponds, the landscape (South Bay and sloughs), and adjacent land uses immediately before *restoration actions* are initiated,
- **impacts**, negative effects on ecological conditions or humans resulting from *restoration actions*, and
- **adaptive management**, monitoring and subsequent actions taken to rectify problems with the restoration or rectify impacts of the restoration.

The model is a guide to the essential structures and processes that must be considered in more detailed modeling. The South Bay salt ponds considered in this study are currently all managed ponds but are currently managed differently than they will be during the restoration project. The ponds are currently managed primarily for salt production and do not discharge to the bay. Under project conditions managed ponds will be operated to benefit wildlife and will include discharges to the bay.

The Managed Pond Conceptual Model flowchart shows the relationship between the eight model components and provides specific conditions or actions for each component. Although this conceptual model describes actions and processes at the pond-level scale, we know ponds are part of a much larger system. Therefore, the flowchart shows the links between the pond and the landscape levels.

Ultimately, the conceptual model will consist of text, flow charts and graphics used to guide scientific and technical planning for the restoration. In addition, a parallel set of products must be produced that is understandable to the public. A central objective of the conceptual modeling effort is to provide information that will educate the public about the ecology of South Bay habitats and the processes and management actions needed to reach restoration goals.

B.3.2 Driving Forces
Driving forces are the structures and processes essential for developing conditions that provide habitat for desired species. These forces are altered or initiated in salt ponds by appropriate restoration actions. The primary forces that provide habitat in managed ponds are:

- **Circulation,** measured by average daily inflow and discharge;
- **Water quality**, measured by salinity, DO, temperature, clarity, etc.;
- **Water depth,** measured as a bathymetry surface relative to NAVD88;
- **Sediment quality**, measured by particle size, chemical composition (especially toxics);
- **Species traits/dynamics,** measured by proximity of species, dispersal ability, abundance, diversity, and productivity of key species.

B.3.3 Restoration Actions: Initiating Driving Forces

To move salt ponds from their initial conditions to conditions that provide improved habitat for desired species requires initiating or altering driving forces. The South Bay Salt Pond Restoration Project will use ongoing management actions and a range of one-time restoration actions, such as installation of hydraulic infrastructure. A partial list of potential actions and the driving forces they alter follows.

Restoration Action	Driving Forces Altered
Installation of hydraulic infrastructure	circulation, water quality, water depth, (including number and locations of gates), sediment quality, species traits/dynamics
Managing inflow to ponds	circulation, water depth, water quality
Seasonal pond management	circulation, water depth, water quality
Pond fill or grading	water depth, circulation, sediment quality
Levee maintenance and improvements	circulation, water depth, water quality
Construction or modification of habitat features	water depth, circulation, water quality
Controlling predators of target species	species traits/dynamics

B.3.4 Constraints on Pond Management

Our ability to manage ponds for habitat value is likely to be constrained by a number of factors in the South Bay. For example, installation and operation of hydraulic infrastructure may be constrained by existing levee heights (to maintain protection from flooding), existing infrastructure, and adjacent land uses. Other managed pond elements and their potential constraints include:

Managed Pond Driving Forces	Potential Constraints on the Driving Forces
Water Depth	Levee elevations, levee erosion, odor, mosquitoes
Circulation	Hydraulic infrastructure, pumping expense,

Water Quality	Intake salinity, limits on discharge salinity to protect slough ecology, odor, disease, mosquitoes
Species Traits	Toxic sediments (Hg contamination), lack of connectivity to existing populations, competition/predation by non-native species, inability to provide all habitat needs (for example, upland refugia)
Uncertainties that may affect many features	Sea-level rise, impacts of Hg on species, effects of new non-native species after restoration is initiated, long-term maintenance of restored habitats by natural forces, overall impacts to wildlife depending on salinity and water levels of open water habitat

This list of constraints focuses on physical and ecological constraints. It is not complete, as other classes of factors must be considered, including economic, regulatory, public interest and technology constraints.

B.3.5 Desired Habitats

To be added

B.3.6 Target Conditions

For managing saline ponds to maximize resource values, the primary factors that determine the communities are tidal exchange, salinity, and water depth. Conditions that characterize South San Francisco Bay managed pond habitats include the following:

- **Circulation** may vary from no tidal exchange to muted tidal ranges less than in adjacent sloughs. Ponds without tidal exchange will be managed as seasonal wetlands that flood with winter rains and dry in the summer, or will require water management by pumping or gravity flow. Seasonal ponds may be particularly valuable as habitat for species that nest in salt flats such as snowy plovers. Ponds with muted tidal inflow through breaches or control structures will provide pond habitats with a variety of salinities and depths. The seasonal timing and extent of flooding from tidal exchange will determine resource values of ponds with tidal inflow.
- **Salinity** may be managed to maximize invertebrate productivity. At low salinities with large tidal exchange, invertebrate communities are similar to those found in the bays and sloughs. At higher salinities, invertebrate diversity and biomass generally decrease, but a unique community occurs in hypersaline ponds of 70-200 ppt when brine flies and brine shrimp dominate. This large prey biomass of this community may benefit migratory birds including migrant species such as shorebirds and phalaropes.
- **Water depth** will determine the availability of invertebrate prey to avian predators. Managing ponds for areas with deep water (>1 m) will attract diving birds, piscivores, and fish, medium depths (0.5-1 m) will attract dabbling birds; and shallow depths (<0.1 m) will be used by probing shorebirds. Shallow impoundments require careful

monitoring and controlled circulation to prevent elevated temperatures and oxygen depletion.
- **Habitat features** such as islands and broad levees may improve the value of ponds for many avian species. Nesting species find protection on islands or cut levees in flooded ponds, while roosting birds use islands extensively during all seasons. Underwater structures may provide habitat used by fishes in deep ponds. Submergent plants such as *Ruppia maritima* are seen in some lower salinity (<70 ppt) ponds. Ponds may be managed for drawdown conditions for a few weeks during the spring to stimulate growth of submergent species that provide valuable substrate for invertebrates.
- **Animal species** may be used as indicators of habitat quality. Species may be divided into abundant species such as western sandpipers, or rare species of management concern such as snowy plovers. The animal species present are controlled by the conditions described above. Important organisms include:
    - Benthic species, such as tubeworms;
    - Brine flies and brine shrimp;
    - Fish species such as longjaw mudsuckers;
    - Bird species, especially shorebirds, waterfowl, and piscivorous birds.

B.3.7 Potential Impacts
Each managed pond is part of a larger pond system, which is integrated into the South San Francisco Bay landscape. As such, each pond is affected by and affects landscape conditions and processes. A few factors that obviously link ponds to the landscape are water quality effects at the discharge points and potential entrainment of species in the intake points.

Management of ponds for habitat value will have potentially negative impacts both within the ponds and at the landscape level. Some of these impacts might be:
- Mercury (Hg) methylation in pond sediments, which could affect the food chain;
- Smells from decomposing algae in the late summer;
- Increased mosquitoes.
- Salmonid entrainment;
- Discharge water quality effects in sloughs, mudflats and fringing marsh;
- Magnified predator effect (fewer ponds -> more concentrated predation);
- Species diversity and abundance changes;
- Disease propagation.

B.3.8 Adaptive Management
Monitoring appropriate parameters to assess progress toward target conditions and to track negative impacts will be an essential part of tidal marsh restoration. When monitoring indicates changes are needed, adaptive management measures may be taken to correct problems that are developing. The measures taken will depend on the nature of the issue being addressed. Some typical problems that arise in tidal marsh restoration and potential adaptive management measures to address those issues are listed here:

Issue to Address	**Adaptive Management Measure**
Inadequate circulation	Change operation or add infrastructure

Salt pond bird species require roosting habitat	Build roosting islands or prevent human access to levees and enhance for roosting
Low dissolved oxygen of discharge	Install aerators; limit discharge during night and morning

B.3.9 Areas of Greatest Uncertainty

To be added

Figure B.3.1. Expected Effects of Restoration Actions on Baseline Conditions for Managed Pond Habitats.

This flowchart gives examples for each of the model components defining the process of managing salt ponds for a number of pond habitats. The general relationship between restoration actions, baseline conditions and effects is indicated. Specific cause-and-effects linkages between elements are not shown; these linkages should be developed in submodels of specific processes.

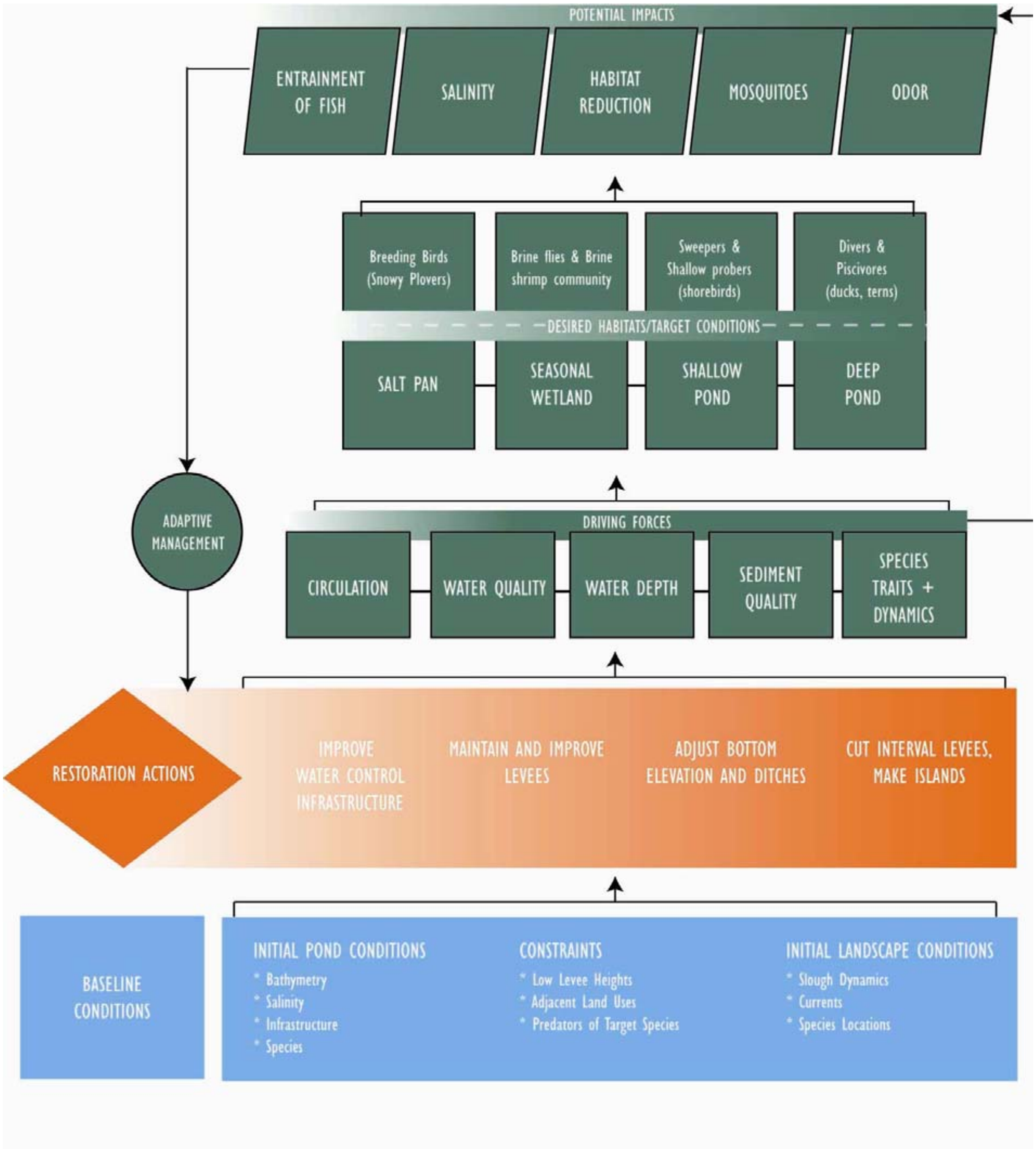


Figure B.3.1. Flowchart for the Managed Ponds Conceptual Model

APPENDIX C - RESEARCH GRANT PROGRAMS

APPENDIX C: RESEARCH GRANT PROGRAMS

Appendix C.1 Proposal for an Academic Research Program

C.1.1 Introduction

The Science Team of the South Bay Salt Pond Restoration Project recommends that the Project encourage involvement of the academic research community in salt pond research and monitoring activities. The Team's motivation for such a recommendation is that sustained and vigorous interaction between managers and local university-based scientists can result in research and monitoring studies that are both cost effective and responsive to agency and stakeholder needs. With this in mind, we propose a new program to encourage academic research in the South San Francisco Bay Salt Ponds through financial and logistical support of graduate students and postdoctoral research associates. Such a program could be funded jointly by the sponsors of the Restoration Project (e.g., California Department of Fish and Game, U.S. Fish and Wildlife Service, and the Coastal Conservancy) as well as, perhaps, the US Army Corps of Engineers and other stakeholders.

The goals of the academic research program (ARP) would be to fill gaps in existing information about wetland features and processes and carry out routine monitoring, thereby facilitating achievement of the objectives of the sponsoring agencies, stimulating academic interest in the salt pond restoration project, and developing a pool of local talent to meet the hiring needs of the management agencies that depend upon technically trained staffs.

C.1.2 Program Scope

C.1.2.1 Research Topics

In general, the scientific scope of academic research should be broadly defined to include all research topics that will advance understanding of the hydrology, physics, geology, chemistry, biology of the South Bay salt pond system, including its local watersheds. Because each funding agency may have topics of particular interest, these will be given special consideration. The achievement of specific agency objectives should, however, not detract from the primary objective of the program which is to support high quality research and monitoring that contributes to the broad goals of South Bay wetland restoration and management.

C.1.2.2 Recipients and their Support

This program will provide research fellowships to either graduate students (MS or PhD candidates) or postdoctoral associates (recent graduates), for a period of 1-3 years. Graduate students should apply in association with a faculty advisor. Postdoctoral applications can incorporate association with either university faculty or agency scientist advisors. Fellowships will provide a stipend to students/postdocs, i.e., full or partial tuition support, *and* a reasonable budget for supplies, publication costs, computing costs, and travel expenses. Additional benefits may include logistical support from a cooperating agency (e.g., shared use of a laboratory or equipment, collection of ancillary data, field support). Fellowships will not provide salary support for advisors (e.g., existing university faculty), for contracts to private for-profit entities, or for the purchase of equipment.

C.1.2.3 Program Size

The ARP should fund, at minimum, three research fellowships annually.

C.1.3 Program Administration

C.1.3.1 Mechanism

This program will award research fellowships that are selected competitively on the basis of scientific merit and relevance of the proposed work to the objectives of the funding agencies. Two functions are required in the administration of the Program: (1) solicitation and evaluation of proposals for new research, and (2) administration of funds to support the research fellowships. Both functions could be coordinated by the Coastal Conservancy, supported by an objective entity such as the Science Team that has scientific stature, a broad mandate, and no potential conflicts of interest. We recommend that the Coastal Conservancy administer the ARP, and the other funding agencies provide the Conservancy with sufficient funds to cover the annual costs of this program. The Conservancy should identify a Coordinator and an office staff person who can each devote part time (perhaps up to three months) to this endeavor. Selection of the Program Coordinator, and subsequent performance evaluations, should be done in consultation with representatives of the funding agencies.

The Program Coordinator will rely upon two panels of volunteers to assist in Program administration:

1. Sponsor Agency Panel - composed of representatives of the funding agencies [Project Management Team?] and Chairperson of the Peer Review Panel (see below).

This panel will determine research topics of high priority (define the scope of the Program), define criteria for proposal evaluation, administer the contracts to the Coastal Conservancy, evaluate renewal proposals (for continuation beyond the first year), and make the final selections of new proposals to be funded. Members of this panel will also serve as liaisons between the universities (i.e., thesis advisor and student) and the funding agency having the most direct connection to the proposed research. These liaisons will be necessary, for example, when active collaboration between the student and an agency is proposed.

2. Peer Review Panel [Science Team?]- composed of scientists actively involved in estuarine or hydrologic research who have a high degree of stature in their fields and some familiarity with the San Francisco Bay-Delta system and its wetlands.

This panel will direct a review of new proposals on the basis of their technical merit including: (a) research scope, and importance of expected results; (b) originality of the hypotheses and experimental design; (c) likelihood of successful completion; (d) soundness of proposed steps for data analysis and synthesis (a critical element); and (e) credentials of the student and advisor. The review will consist of (a) external (mail) reviews by experts, and (b) ranking of proposals based on the Panel's own evaluation and the external mail reviews. The Coordinator must ensure that the Peer Review Panel members have no conflicts of interest (e.g., current or pending student support from the Restoration Project).

C.1.3.2 Annual Timetable

The annual cycle begins December 1 with a request for proposals to be distributed by the Coastal Conservancy Coordinator. Candidates, in consultation with their advisors (and any collaborating staff of the funding agencies), prepare proposals following published guidelines; deadline for submittal is May 1. After this deadline, the Coordinator convenes the Agency Panel (AP) to screen all new proposals. Those judged to be beyond the scope of the Program are returned, un-reviewed, with a written explanation. The Coordinator next convenes a Peer Review Panel (PRP). The PRP members jointly arrange for external review of all screened proposals that should be completed by August 1. By August 15, the PRP re-convenes and ranks all new proposals, based on their scientific merit, with numerical ratings from 5 (Excellent) to 1 (Poor).

Based on reviewer ratings, relevance of proposals to agency missions, practicality of management implications, and availability of funding, the Agency Panel determines which new proposals will be funded during that fiscal year. In their deliberations, the AP will give most serious consideration to those proposals rated 4 or 5 by the PRP, and will not select proposals rated 1 or 2. The AP should also strive for a balance in the distribution of support among MS candidates, PhD candidates, and postdocs.

By September 15, the awards are announced and the Coordinator initiates the transfer of funds to the appropriate universities to support the awarded fellowships. Research begins in the period October 1 to May 1, and is supported for one year.

Note that existing proposals can be renewed on an annual basis, up to two times, and these renewals are based on evaluations by the AP that proceed in parallel with that Panel's ranking of new proposals. This evaluation will require, in each instance, a short renewal proposal; a brief progress report (perhaps including a public talk such as at the California Bay-Delta Program/CALFED Science Conference, or an agency report); evaluation from the collaborating agency, if one exists; and a plan for the release of study findings. It is imperative that sponsoring agencies give the Program a high priority for funding to ensure its continuity once begun. Hence a mechanism should be found to dampen year-to-year fluctuations in funding, and to guarantee continuity of support once an award is made.

C.1.4 Format and Content of Proposals

The text of a proposal should not exceed six single-spaced pages, and should use the following format as a guide:

<u>A. Text</u>

1. Statement of the Problem (hypothesis)
2. Approach (experimental design, methods, coordination with existing research programs, data analysis and synthesis, plan for publication of findings)
3. Relevance to ongoing Research/Monitoring Programs (including discussions and collaboration with funding agencies)
4. Cited References

B. Credentials
1. CV's (student and advisor)
2. Student transcripts
3. Brief Statement of Personal Goals written by the student

C. Budget, with justifications

C.1.5 Program Initiation

The following steps must be completed by June 1, 2004, to allow funding of new graduate student research during FY2005 [*although organization and funding realities may require a delay in the start of this program, even if approved*]:

1. Representatives from Project Management Team must meet to discuss this proposal, reach a consensus on changes/amendments to this proposed scheme, determine program size for FY2005, and select an initial Agency Panel.
2. The Agency Panel should write a contract to support the Coastal Conservancy Coordinator and staff for 2004-5.
3. The Conservancy, with the AP, should select a Coordinator.
4. The AP and Coordinator should produce a pamphlet for distribution prior to the Request for Proposals. This pamphlet should announce the Program, define its scope, describe the format for proposals, define criteria for making awards, identify high priority research topics, and prescribe accountability of fellowship recipients.
5. The Coordinator should begin the cycle by distributing the pamphlet and RFP to all candidate universities as determined by the AP.
6. It is probable that first awards could be made as early as September 15, 2005.

APPENDIX C: RESEARCH GRANT PROGRAMS

Appendix C.2 Proposal for a Focused Research Program

C.2.1 Introduction

Successful restoration of the South Bay salt ponds will be dependent on the resolution of a broad spectrum of technical, policy and funding questions. In recognition of the technical challenges facing the development and implementation of a restoration plan for this vast and diverse array of ponds, much effort has been directed to the identification of technical questions that need to be answered (California Coastal Conservancy et al. 2003 a, b; Siegel and Bachand 2002). Among the many questions posed by the participants in several open workshops are particularly challenging questions for which answers will not be achieved without a commitment to new targeted or "focused" field and/or laboratory research studies specifically designed to provide well documented and scientifically credible information and answers. Because of the number and complexity of some of the key questions, it will be necessary to be very selective in choosing the questions to be addressed and the teams that will be asked to carry out the required studies. In short, the South Bay Salt Pond Restoration Project should put in place a competitive research funding program, the "South Bay Salt Pond Focused Research Program", that provides the mechanism through which awards can be granted to those study teams that demonstrate the best ability to address the most important questions.

In the broadest sense, the goals of the South Bay Salt Pond Focused Research Program are to build an understanding of physical, chemical, and biological processes in the salt ponds and their watersheds that are relevant to South Bay Salt Pond Restoration Project actions; provide information useful in evaluating the appropriateness of different restoration strategies, and the appropriateness of monitoring attributes; test causal relationships among environmental variables identified in salt pond conceptual models; reduce areas of scientific uncertainty regarding management actions; incorporate relevant new information from other research; and revise conceptual models as our understanding increases. More specifically, the Focused Research Program is needed to support staged implementation of the Restoration Project, to investigate the constraints and impacts of restoration, and to document and explain trends detected in monitoring data.

To accomplish the above objectives, the sponsoring agencies, through the Restoration Project's management and technical workteams, will compile a reasonably short list of those research questions that are relevant to key issues that need to be resolved during the early stages of Restoration Project development. The sponsors' approved list of research questions would serve as the basis for issuing a series of Requests for Proposals (RFPs) soliciting proposals from the scientific community for research directed toward answering the critical questions.

In addition, specific research questions could become the focus of a "Directed Research Program" coordinated by the sponsoring agencies, with guidance from the Science Team. Under this program, individual scientists and teams of scientists would be contracted on a non-competitive basis to carry out longer-term research projects to achieve specific South Bay Salt Pond Restoration Project technical objectives.

C.2.2 Research Program Development

C.2.2.1 Management

The South Bay Salt Pond Restoration Project research program will be managed under the auspices of the Coastal Conservancy, and headed by an overall coordinator – the Focused Research Program Coordinator ("Coordinator"). The Coordinator could be a Coastal Conservancy employee or an employee of some other independent entity who will be responsible for day-to-day coordination of the development of lists of study questions, the design and dissemination of the RFPs, and the proposal review process (see a draft of the proposed review process below). This individual would work with the South Bay Salt Pond Science Team and representatives of agency sponsors to develop the RFPs. The Coordinator would facilitate the distribution of funding to the proponents of successful new and renewal proposals, and the Chairman of the Science Team would facilitate the proposal review process.

C.2.2.2 List of Research Questions

A preliminary assessment of South Bay Salt Pond research needs will be carried out by sponsoring agency staffs, with input from the Project Management, Science, and Consultant Teams, through a review of Program documents and queries of program managers about the actions proposed and management questions associated with each restoration objective. Based on these queries and on existing knowledge (as summarized in published literature), a preliminary list of research questions will be created. In some cases, *ad hoc* subject-matter technical teams may be necessary to review, refine, and prioritize the questions posed in each technical area. The list of questions so developed would then be submitted for review and overall prioritization by a Sponsoring Agency Panel comprising representatives of the funding agencies and the Chairperson of the Science Team, with input from the Science Team as requested. The final list of questions would then be published and disseminated in an RFP.

In subsequent years, the development of lists of research questions would be based on findings to date in ongoing studies, questions raised in the course of conducting the Restoration Project monitoring, assessment and research programs, or in other related studies.

C.2.3 Calls for Proposals

When the list of approved study questions has been developed, one or more RFPs, designed to solicit proposals for addressing the identified study questions, would be prepared by the Project's sponsoring agencies and 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).

C.2.3.1 Pre-Proposals

It is expected that the South Bay Salt Pond Focused Research Program will result in the submittal of many 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, and to reduce the workload of the proposal reviewers, the South Bay Salt Pond Focused Research Program will require that all proposals under this program be preceded by a brief pre-proposal. Pre-proposals will be reviewed by the sponsoring agency staff, assisted by the Science Team to ensure that the proposed work is responsive to the RFP, that the proposed work has apparent scientific merit, and that the funding request seems reasonable. Only the Principle Investigators of those pre-proposals that are responsive and reasonable will be asked to submit full proposals. The non-responsive or incomplete pre-proposals will be returned to the proponents with the request that full proposals not be submitted at this time.

C.2.3.2 Proposals

Each proposal study plan must contain 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 for all Focused Research Program proposals:

1. *Cover sheet* - A transmittal document that includes the RFP 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 an SFEI database.

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.

C.2.4 Proposal Review Process

The South Bay Salt Pond Focused Research Program 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 will require instituting an objective process for the anonymous peer evaluation of proposals for new research that is efficient and achieves broadest acceptance of the process within the scientific and resource management communities.

To provide overall direction of the review process, an individual having high scientific stature, a broad mandate, and no potential conflicts of interest, will be appointed Chairman of the Peer Review Coordination Panel (“Review Panel”). This individual would work with the Focused Research Program Coordinator to develop and carry out the review process. The Chairman would be provided with sufficient funds to cover his/her costs (salary and expenses).

The review process comprises a three-tiered system:

- The Peer Review Panel [Science Team?];
- Technical experts who are solicited by the Peer Review Panel members, perhaps with honoraria for non-agency participants, to provide the first level of anonymous review.
- An Agency Panel that will select the projects to be funded based on the results of the peer review and the priorities of the sponsoring agencies.

C.2.4.1. Peer Review

The Peer Review Panel would comprise a group of 10-15 technical experts. If so desired, the role of the Review Panel could be assumed by the Science Team. The members of the Peer Review Panel 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-Delta-watershed system. The Focused Research Program Coordinator would ensure that panel members have no conflicts of interest (e.g., current or pending support from the Program).

The members of the Peer Review Panel will be tasked with soliciting and overseeing the anonymous external (mail) review of proposals. This will be accomplished by having each individual member solicit reviews by at least three experts for each proposal within his/her specialty areas, then summarize and prioritize the member's findings for presentation to the other members of the panel.

The transmittal letter from the member of the panel to a potential reviewer should identify the goals and objectives of the Program, inform the recipient of the importance of his/her participation in the peer review process, and indicate a specific date by which the completed review is to be returned. The letter should advise the recipient that if he/she cannot provide the requested review or cannot meet the suggested deadline, the document should be returned immediately, whereupon the panel member shall select another reviewer.

Reviewers will score the proposals, based on their scientific merit and the relevance to the RFP, 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 RFP.
- 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

If so required by the Peer Review Panel, the Principal Investigator may be given an opportunity to incorporate changes as suggested by the peer reviewers in a revised study plan. If the Principal Investigator challenges the recommendations of the peer reviewers, a written rebuttal with justification must be provided for archiving with the revised study plan. Principal Investigators should focus their rebuttal on substantive review comments (e.g. theory, techniques, objectives, and statistics) and simply incorporate non-substantive comments (grammar, style, typographical, formatting) if the comments are appropriate.

The revised study plan, signed by the Principal Investigator with accompanying rebuttals, is returned to the Focused Research Program Coordinator for referral to the Peer Review Panel. At the discretion of the Peer Review Panel, the Principal Investigator may be required to submit the study plan for additional peer review. In any event, a revised study plan will be submitted to the Review Panel for its final review and recommendation.

When all reviews have been received, the proposals will be ranked within each topical category by the Peer Review Panel based on the external mail reviews and the Panel's own evaluation. The panel will develop an overall prioritization of the proposals and will transmit its funding recommendations to the South Bay Salt Pond Focused Research Office for forwarding to the Sponsoring Agency Panel.

C.2.4.2 Sponsoring Agency Review

The Sponsoring Agency Panel [Project Management Team?] 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 RFP. The Agency Panel, in its deliberations, 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 Agency Panel will also evaluate renewal proposals for continuation beyond the first year. The Focused Research Program Coordinator will oversee the administration of funds to support the research efforts.

C.2.5 Directed Research 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 sponsoring agencies 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 RFP process.

Such questions, identified by the Science Team and sponsoring agency representatives, 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 RFP format described above, that will be subject to review and concurrence (or rejection) by the Science Team 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 six 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, 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.