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FINAL
Parsons Slough Complex Wetland Restoration Plan

Prepared for:
California State Coastal Conservancy

By:
ESNERR and Moffatt & Nichol

with assistance from:
Wetland and Water Resources
FarWest Restoration Engineering
Chambers Group, Inc.

FINAL PARSONS SLOUGH COMPLEX WETLAND RESTORATION PLAN

Prepared for:

California State Coastal Conservancy
1330 Broadway Avenue, 13th Floor
Oakland, CA 94612-2530

By:

Elkhorn Slough National Estuarine Research Reserve
1700 Elkhorn Road
Watsonville, CA 95076

and

MOFFATT & NICHOL

With Assistance From:

Chambers Group, Inc.
Wetland and Water Resources
and
FarWest Restoration Engineering

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PARSONS SLOUGH WETLAND RESTORATION PLAN

TABLE OF CONTENTS

CHAPTER 2 FIGURES

CHAPTER 2 TABLES

CHAPTER 2 APPENDICES

CHAPTER 3: ANALYSIS OF ALTERNATIVES

CHAPTER 3 FIGURES

CHAPTER 3 TABLES

CHAPTER 3 APPENDICES

CHAPTER 4: PARSONS SLOUGH RESTORATION PLAN

CHAPTER 4 FIGURES

CHAPTER 4 TABLES

CHAPTER 4 APPENDICES

EXECTIVE SUMMARY

TABLE OF CONTENTS

PARSONS SLOUGH
WETLAND RESTORATION PLAN

EXECUTIVE SUMMARY

The Parsons Slough Wetland Restoration Project is the first implementation project of the Elkhorn Slough Tidal Wetland Project (TWP), an initiative of the Elkhorn Slough National Estuarine Research Reserve (ESNERR) begun in 2004. TWP is a collaborative effort to develop and implement strategies to conserve and restore estuarine habitats in the Elkhorn Slough watershed. It involves over a hundred coastal resource managers, representatives from key regulatory and jurisdictional entities, leaders of conservation organizations, scientific experts and community members. The Elkhorn Slough Tidal Wetland Strategic Plan (2007) published the following findings of this planning process: (1) Over the past 150 years, human actions have resulted in substantial tidal marsh loss, subtidal habitat erosion, increased levels of pollution and increased numbers of invasive species; (2) Approximately 50 percent, or 1,000 acres, of the tidal marsh in Elkhorn Slough has been lost since 1870 due to human activities; (3) Bank erosion rates along the main channel of Elkhorn Slough range from 1 to 2 feet per year; (4) These rapid changes affect the estuary's animals and plants, threaten the biodiversity of the estuary and impact neighboring private lands, public access sites, and other infrastructure; and (5) Marsh loss and habitat erosion will likely continue at high rates if no action is taken.

The Tidal Wetland Project's overarching goals for the Elkhorn Slough Estuary strive to: (1) Conserve the highest quality estuarine habitats and native biodiversity; (2) Restore and enhance estuarine habitats with special emphasis on those with the highest loss rates; and (3) Restore and enhance natural processes to sustain a more stable and resilient estuarine system. A summary of the planning process, including complete planning statements can be found at www.elkhornslough.org/tidalwetland/description.htm.

The Parsons Slough Complex is a central part of Elkhorn Slough. Its history of extensive land disturbance and its conservation ownership made this site a particularly strong candidate for ecological restoration. At 429 acres it comprises 16 percent of the Slough's 2,690 acres. Nearly all of it is owned by the California Department of Fish and Game. The earliest maps indicate the area was once entirely dominated by tidal marsh and tidal creeks. Over time, diking and draining for agriculture and other uses altered the plant cover of the entire site, and ultimately caused the land surface to subside (drop in elevation). The land was excluded entirely from tidal exchange for several decades ending in 1982 when tidal exchange was returned through both intentional and accidental levee breaches. By then the land surface was two to three feet below that needed to sustain a healthy tidal marsh. The former farm fields and drained lands now support intertidal mudflat and subtidal channels, which support a variety of wildlife, particularly shorebirds and fish species, particularly elasmobranches. Because the land surface is lower than the rest of Elkhorn Slough, the Parsons Slough Complex now contributes a disproportionately large fraction (37%) of the total Elkhorn Slough tidal exchange. The channel of Elkhorn Slough has deepened and widened each year since the opening of the Parsons Slough Complex to accommodate this additional volume of water. Approximately 100,000 cubic meters (m^3) of sediment are exported from Elkhorn Slough annually by this process.

This report documents the first formal assessment of the restoration opportunities for the area since the early 1980s. To guide the process, a partnership, the Parsons Restoration Team, was formed in 2007 between the Elkhorn Slough Tidal Wetland Project, the State Coastal Conservancy, and an advisory panel comprised of experts in coastal resource management and tidal wetland restoration. The Parsons Restoration Team was tasked with developing a restoration plan for the Parsons Slough Complex. That team hired and worked closely with a team of consultants who conducted technical analysis and document preparation. That team included Moffatt and Nichol, the Chambers Group, Wetlands and Water Resources and FarWest Restoration Engineering, each leaders in the field of coastal habitat restoration.

A.1. Project goals: A Synopsis

The Parsons Restoration Team set goals and objectives for the project that stem from an over-arching vision, established by the Tidal Wetland Project, which aims to conserve and restore estuarine habitats in Elkhorn Slough.

Goal 1: Restore and enhance intertidal marsh habitats and functions within the Parsons Slough tidal wetland complex while addressing the needs of special-status species, estuarine-dependent species, and ongoing human uses.

Goal 2: Support the ecological recovery of the larger Elkhorn Slough system to the extent possible while meeting Goal 1.

Goal 3: Conserve high quality subtidal and intertidal estuarine habitats and functions within the Parsons Slough tidal wetland complex.

A.2. Plan outline

The Plan is composed of the following individual components:

- An introduction, including project goals and objectives (Chapter 1);
- An assessment of existing conditions (Chapter 2);
- Analysis of several restoration alternatives including the evaluation of options for sediment additions for tidal marsh restoration (Chapter 3), and
- Formulation of a strategy to implement the project goals (Chapter 4).

Each component of the plan was presented as an individual draft document for public review and input. During the planning process, four public meetings were held. This final restoration plan document incorporates public, stakeholder, and advisory team input.

A.3. Existing Conditions

Available data were reviewed to characterize existing conditions and identify data gaps.

Habitats include mainly high quality mudflat and channels. These areas support invertebrates and fishes as a prey base for larger predators, and serve as a nursery for sharks, rays, and juvenile fish. Vegetated intertidal habitat is sparse, degrading, eroding, and of poor quality.

Tidal conditions are full tidal and lag times are minimal. Tidal flow velocities at the Union Pacific Railroad bridge are approximately 5.6 feet per second (1.7 meters per second) on ebbing tides and 4.9 feet per second (1.5 meters per second) during flooding tides. These velocities are sufficient to erode sediments from the channel. Continuing erosion would widen and deepen the channels at the expense of remaining salt marsh and mudflat, and would degrade the habitat function of the channels and mudflat as has happened elsewhere in Elkhorn Slough.

Existing sediments are a thick layer of soft silts in areas sampled near the main tidal channel and they do not possess contaminants. The site has subsided due to possible head-cutting of the main entrance channel, tidal scour from increasing tidal prism, residual effects of former diking/draining/farming, and reduced inputs of sediment from the watershed. This trend is projected to continue over time.

The watershed contributes relatively small freshwater volumes to the Parsons Slough Complex having a minor and temporary effect on water quality. Water quality is relatively good compared to other areas of Elkhorn Slough and is typical of saltwater wetlands in populated and agricultural areas. Periods of low dissolved oxygen occur in summer and fall seasons. These conditions are short-term and stress the habitat causing a seasonal constraint.

Anthropogenic features exist at the site posing potential constraints including the railroad line, two bridges, levees, culverts, overhead power lines and support towers.

A.4. Options for Sediment Additions to Rebuild Marsh Habitat

The Parsons Slough Complex requires sediment additions to raise the existing grade relative to the tides to restore fully tidal salt marsh. This chapter identifies potential sediment sources, presents initial restoration alternatives, prioritizes locations for sediment placement, reviews and evaluates sediment addition techniques, and summarizes regulatory issues associated with these actions.

Approximately 2.3 million cubic yards of sediment needs to be added to raise the Parsons Slough Complex to the elevation suitable for large-scale colonization of vegetated salt marsh across the entire site (except for tidal channels). Sediment sources exist within the region both upland and offshore. Upland sources include materials both within and outside of the watershed. Sources include lakes, farms, road right of ways, development sites, flood control facilities, and quarries. Dry material sources are suitable for trucking and transport by train, with earthmoving as one placement method. These upland construction methods are disturbing to the environment at the scale required to transport 2.3 million cubic yards of sediment.

Aqueous sources include local harbors and navigable waterways, the nearshore ocean, and the offshore ocean. Material from aqueous sources, particularly from the marine environment, may be immediately suitable for use in establishing vegetated salt marsh habitat assuming the material grain size is appropriate. Both the risk of importing non-native invertebrates and sediment quality would require evaluation. Wet sediment could be pumped hydraulically through a pipeline to the site as a slurry. Delivering wet sediment to the Parsons Slough Complex by barges or scows is not possible due to the low clearance under the UPRR bridge on-site. Barge delivery through Elkhorn Slough is also constrained by low clearance under Highway 1 Bridge at Moss Landing.

A promising source appears to be a local quarry accessible by truck and rail, the Wilson Quarry owned by Graniterock, Inc. The quarry produces large quantities of a crushed rock dust by-product that is fine in grain size and inert in chemistry. A slurry line is likely the most effective conveyance mode for this material. Better understanding of the material properties of this granite dust as a substrate for habitat is required before it could be recommended for a large-scale restoration project.

Locations for sediment addition were prioritized based on a ranking system that considers construction access, available working/staging areas, area of new vegetated marsh created for sediment added, reduction in tidal prism, general environmental impacts, proximity to local sources, containment feasibility, and likely construction costs. The prioritized areas for placement are:

1. The Five Fingers (equally beneficial as the 6th Finger);
2. The 6th Finger;
3. Rookery Lagoon;
4. The greater South Marsh Area; and
5. The Central/West Marsh South of the Main Channel.

Preliminary estimates indicated that the cost to restore fully tidal salt marsh in Parsons Slough by sediment addition would be substantial at $80,000 per acre or more. There may be areas of Elkhorn Slough closer to sediment sources where a similar approach can be applied in a more cost effective manner. Implementing such a project would require permits from local, state and federal agencies.

A.5. Analysis of Restoration Alternatives

Three wetland restoration alternatives and several subalternatives were evaluated. Analyses were performed with respect to:

- Tidal Hydrology and Hydraulics;
- Water Quality;
- Sea Level Rise;
- Habitat Changes;
- Potential Impacts to the Railroad Levee and Related Structures;
- Maintenance Requirements;
- Estimated Construction Costs;
- Preliminary Environmental Review;
- Compatibility with Future Sediment Additions and/or The Larger Elkhorn Slough Project; and
- Consistency with Project Goals and Objectives.

Alternatives considered included:

No Project: Existing conditions are maintained. The No Project Alternative would preserve existing habitat conditions and processes and prevents disturbance from construction operations. It precludes restoration actions to offset losses of salt marsh and proactive measures to anticipate sea level rise. The site would eventually transition completely to a subtidal basin, with a larger tidal prism that increases the scour and marsh loss in Elkhorn Slough. This would likely contribute to a loss in habitat diversity in Elkhorn Slough. This alternative is not consistent with project goals and objectives.

Alternative 1 Description: A high water control structure (+9 feet elevation (North American Vertical Datum) NAVD)) with culverts and tide gates in the main Parsons Slough entrance channel at the Union Pacific Railroad (UPRR) Bridge levee. This would arrest channel scour, mute tides and lower mean water levels such that the existing land surface would support tidal marsh.

Alternative 2 Description: A subtidal sill (with the crest at -2 feet NAVD) in the main Parsons entrance channel downstream of the UPRR Bridge. This would arrest channel scour and contain sediment within the Parsons Complex. It would be coupled with sediment additions at large and/or small scales behind internal dikes, which would enable the re-establishment of tidal marsh vegetation.

Alternative 3 Description: Dikes would be built across various portions of the Parsons Complex, with either open channels or culverts and tide gates connecting these areas to the rest of the Parsons Complex to enable varying degrees of tidal muting. Sediment additions would enable the re-establishment of tidal marsh vegetation.

A.6. Recommended actions

The strengths and weaknesses of these alternatives were considered in detail, with two major outcomes:

- Restoring fully tidal salt marsh in the Parsons Complex is likely to be costly and to require substantial additional technical analyses.

- A simpler project that prioritizes the preservation of existing high quality habitat in both Elkhorn Slough and the Parsons Complex could be implemented at a small fraction of the cost of a project that restored extensive tidal marsh.

Following consideration of these alternatives, the Parsons Slough Restoration Team (PRT) recommended eliminating many of them. The PRT eliminated Alternative 1 and all of the subalternatives of Alternative 3 that involved lowering the tidal frame. These were considered likely to result in undesirable water quality conditions in the Parsons Slough Complex, a lack of connectivity between the resulting marsh and the rest of the estuary, a lack of resilience to sea level rise, and high operations and maintenance costs. In essence, the PRT determined that the Elkhorn Slough estuary has hundreds of acres of salt marsh with severely restricted tidal exchange, that these sites exhibit diminished ecologic function, and that the best use of the Parsons Complex was not to increase that acreage.

Alternative 2 was the only alternative that would advance all three project goals, restoring fully tidal salt marsh to the Parsons Slough Complex. Verifying the feasibility of Alternative 2 will require additional technical investigations to evaluate the suitability of sediment for addition. With a projected cost of approximately $50 million and in the context of the current economic crisis, this alternative was not viewed as the highest priority.

ESNERR staff recommended a project to advance Goals 2 and 3: preserve declining habitats in Elkhorn Slough while conserving high quality subtidal and intertidal habitat in the Parsons Slough Complex. That project, the Parsons Slough Sill, would consist of an adjustable water control structure that would be operated concurrent with a monitoring program to ensure adverse impacts are avoided. This project was endorsed by a joint meeting of the Strategic Planning Team and Science Panel of the Tidal Wetland Project in June 2009.

The Parsons Slough Sill would involve placement of a water control structure as a submerged tidal barrier across the mouth of Parsons Slough. The structure would result in some muting of the tides, but much less than Alternative 1. The reduction in tidal prism would reduce current velocities and tidal scour in the main channel of Elkhorn Slough, advancing Goal 2. The structure would be adjustable over a range of configurations to enable optimization among multiple management objectives, such as maintaining sufficient tidal exchange to preserve water quality in Parsons Slough. An open channel geometry with an invert elevation of -5 feet NAVD would provide passage for fish and wildlife, advancing Goal 3. This project would be compatible with but not dependent on the later implementation of a large scale sediment addition project to advance Goal 1 in the future. The estimated cost to design, permit and build this project is $4 million, a fraction of the cost of the other alternatives.

Based on modeling by Moffatt and Nichol, reported in an appendix to Chapter 4, the sill in its most open setting would preserve the existing tidal range, tidal prism and residence time of water in Parsons Slough. In its most restricted setting, the tidal range would be reduced by approximately 50%, the tidal prism of Parsons Slough would be reduced by approximately 30% and peak current velocity in the main channel of Elkhorn Slough would be reduced approximately 20%. That reduction in ebb current velocity is expected to reduce tidal scour in Elkhorn Slough and help shift the hydrodynamics and geomorphology of the estuary towards conditions more likely to sustain salt marsh and soft subtidal habitats in the future.

The long term effort to restore salt marsh in Elkhorn Slough remains a priority of the Tidal Wetland Project and the PRT. Sediment addition will remain under consideration as a potential restoration option. Further evaluation of the viability and environmental impacts of sediment addition will be required to determine whether this approach is advisable.

A.7. Next steps

The next steps for restoration are:

- Advance the implementation of the Parsons Slough Sill by funding and managing the design, environmental compliance and construction phases.
- Evaluate available sediment through experiments and/or trial restoration projects.
- Identify the highest quality mudflat and subtidal habitat, which sediment addition projects should avoid. The process should engage scientists, naturalists and other stakeholders knowledgeable of the Parsons Slough Complex and its existing use of the site by sharks and rays, sea otters, harbor seals, and shorebirds.
- Identify and explore strategies for reducing the costs of sediment delivery and placement.
- Evaluate the costs and benefits of tidal marsh restoration in the Parsons Slough Complex compared to other sites in Elkhorn Slough, such as the ESNERR properties, Minhoto and Pick-N-Pull.
- In light of the findings related to cost, feasibility and habitat quality, select the locations of sediment additions, and refine the target proportions of salt marsh, mudflat and subtidal habitats.
- Determine whether and how to proceed with subsequent implementation steps.

CHAPTER 1

INTRODUCTION

TABLE OF CONTENTS

INTRODUCTION

1.1. Background/Summary of Problem to be Addressed

Elkhorn Slough, an estuary located on the Central California Coast, provides a rich ecosystem for over 780 aquatic bird, marine invertebrate, marine mammal, and fish species. Elkhorn Slough is an important nursery for commercially and recreationally harvested fish and a premier migratory stopover for birds. In the Elkhorn Slough watershed, there are over two dozen rare, threatened, or endangered species. The estuary provides many beneficial uses, including boating and kayaking, hiking, educational experiences, and research opportunities. The hundreds of acres of coastal wetlands also decrease shoreline erosion, reduce flooding, and filter polluted waters. Elkhorn Slough is recognized as a Globally Important Bird Area and Western Hemisphere Shorebird Reserve.

Unfortunately, the estuarine habitats of Elkhorn Slough are undergoing rapid change. The soft channel bed is being scoured away. Parts of the channel have deepened by 20 feet. This is the result of the subsidence of formerly drained wetlands and the opening of the harbor mouth at Moss Landing in 1947, which exposed the slough to the full tidal range of the ocean (Elkhorn Slough Tidal Wetland Project Team, 2007). High current velocities resulted in the erosion of the channel bed and banks. This tidal scour has enabled oceanic tides to propagate farther into the slough, effectively raising the height of high tide throughout the estuary by approximately one foot over the past sixty years. Hundreds of acres of salt marsh, now flooded too much of the time, are dying. The estuary once supported 2000 acres of salt marsh, but is projected to host just 240 acres by the year 2050 under a ‘no action’ scenario (Philip Williams and Associates, et al. 2008). Other processes potentially contributing to the dieback of the marsh vegetation include the diversion of fluvial sediment sources, deep subsidence associated with groundwater extraction, and shallow subsidence related to the disruption of soil accretion by increased nutrient inputs (Elkhorn Slough Tidal Wetland Project Team, 2007).

These changes have severe impacts. The loss of soft subtidal habitats affects the diverse and highly productive invertebrate community, which forms the base of the estuarine food web. The many functions of salt marsh, such as water quality improvement and habitat structure, are being lost. Highly productive mudflats, shellfish beds, eelgrass beds and salt marsh are eroding, as is critical infrastructure such as levees.

The project called for in Chapter 4 of this restoration plan will address a major root cause of these problems: the daily tidal exchange into and out of Parsons Slough, which has increased approximately five-fold compared to pre-development conditions (Philip Williams and Associates et al., 2008). In Parsons Slough, a major branch of the estuary, roughly 400 acres of salt marsh were drained during the period from 1903 to 1982. While drained, the land surface subsided (dropped) by several feet. The tides were returned by the intentional and accidental breaching of dikes in 1982-83. The additional water that fills and drains the area each day is a major contributor to the process of tidal scour, which has impacted salt marsh and soft subtidal habitats throughout Elkhorn Slough.

This plan accomplishes three objectives in the three chapters that follow: Chapter 2 characterizes the existing and historical conditions of Parsons Slough. Chapter 3 describes and evaluates restoration alternatives intended to restore historical habitats to the Parsons Slough and rebalance the ecologic processes that sustain wetland habitats in the estuary. Chapter 4 lays out a road map for the implementation of restoration projects, and for the evaluation of remaining areas of uncertainty.

1.2. Project Goals and Objectives

The Parsons Slough Wetland Restoration Project is the first project to arise from the Elkhorn Slough Tidal Wetland Project (TWP), a collaborative effort to develop and implement strategies to conserve and restore estuarine habitats in the Elkhorn Slough watershed. TWP involves over a hundred coastal resource managers, representatives from key regulatory and jurisdictional entities, leaders of conservation organizations, scientific experts and community members. TWP has made the following findings about the Elkhorn Slough wetland ecosystem: (1) Over the past 150 years, human actions have resulted in ongoing marsh loss and estuarine habitat erosion and increased levels of pollution and invasive species; (2) Approximately 50 percent, or 1,000 acres, of the tidal marsh in Elkhorn Slough has been lost since 1870 due to human activities; (3) Bank erosion rates along the main channel of Elkhorn Slough range from 1 to 2 feet per year; (4) These rapid changes not only affect the estuary's animals and plants, but also impact neighboring private lands, public access sites, and railroad and road infrastructure; and (5) Marsh loss and habitat erosion will likely continue at high rates if no action is taken.

The Tidal Wetland Project's overarching goals for the Elkhorn Slough Estuary strive to: (1) Conserve the existing highest quality estuarine habitats and native biodiversity; (2) Restore and enhance estuarine habitats with special emphasis on habitats with the highest loss rates; and (3) Restore and enhance natural processes to sustain a more stable and resilient estuarine system. (Elkhorn Slough Tidal Wetland Project Team, 2007) The Tidal Wetland Project web site www.elkhornslough.org/tidalwetland/description.htm provides the complete planning statements. The Parsons Slough Wetland Restoration Project Goals and Objectives incorporate the over-arching vision that aims to conserve and restore all estuarine habitats.

Goal 1: To restore and enhance intertidal marsh habitats and functions within the Parsons Slough tidal wetland complex while addressing the needs of special-status species, estuarine-dependent species, and ongoing human uses.

Objectives:

1.1 Produce the appropriate physical conditions that support ecological and hydrologic functions of vegetated intertidal marsh and its associated tidal creeks, pannes, and upland transitional habitat areas. Aim to significantly increase the extent of vegetated marsh plain.

1.2 Evaluate design approaches that include phased implementation of (a) sediment additions over a multi-year or decadal time frame to raise elevations and/or (b) water control structures to mute the tides to produce the appropriate physical conditions to support intertidal marsh.

1.3 Enhance habitat conditions for threatened and endangered species, species of concern, and estuarine-dependent species, provided enhancements are consistent with the long-term survival and persistence of all such species.

1.4 Incorporate the following concepts into restoration approaches:
- Promote solutions that draw upon natural processes in the long-term such as re-establishing natural sedimentation from organic or inorganic sources;
- Minimize the need for active operations and maintenance activities; and
- Provide for flexible site management over time in the context of changes within Parsons Slough.

1.5 Develop restoration designs that do not exacerbate or negatively impact the following:
- Presence of non-native species;
- Seawater intrusion to adjacent private lands;
- Scour and flooding effects on the railroad embankment and bridge; and
- Existing human uses outside the project area including kayaking, boating, fishing, and harbor maintenance.

1.6 Minimize the magnitude and duration of adverse water quality conditions and seek to improve long-term water quality in recognition that reducing the tidal prism could reduce tidal flushing.

1.7 Accommodate up to 3 feet of sea-level rise projections in potential restoration approaches.

1.8 Identify approaches that accommodate phased implementation in the context of variable future funding levels.

Goal 2: To support the ecological recovery of the larger Elkhorn Slough system to the extent possible while meeting Goal 1.

Objectives:

2.1 Produce the desired inundation regime that supports ecological and hydrologic functions of vegetated intertidal marsh and its associated tidal creeks, pannes, and upland transitional habitat areas. Aim to maximize the extent of vegetated marsh plain.

2.2 Develop restoration designs that provide for adaptive site management over time in the context of possible future conditions of the larger Elkhorn Slough system.

Goal 3: To conserve high quality subtidal and intertidal estuarine habitats and functions within the Parsons Slough tidal wetland complex.

Objective:

3.1 Accommodate nursery and foraging habitat for estuarine fish species to the extent practical.

1.3. Planning Process

The Parsons Slough Restoration Plan is a product of the Elkhorn Slough Tidal Wetland Project. The Tidal Wetland Project is a collaborative effort, initiated in 2004, to develop and implement strategies to conserve and restore estuarine habitats in the Elkhorn Slough watershed. It involves over a hundred coastal resource managers, representatives from key regulatory and jurisdictional entities, leaders of conservation organizations, scientific experts and community members. In its 2007 Elkhorn Slough Tidal Wetland Strategic Plan, the Tidal Wetland Project Team identified the restoration of Parsons Slough as a priority project.

Later that year, the Parsons Slough Restoration Plan was funded by the State Coastal Conservancy (SCC) and the Environmental Protection Agency through the Wetlands Projection Development Grant Program. The SCC worked closely with the Elkhorn Slough National Estuarine Research Reserve (ESNERR) and the Elkhorn Slough Foundation (ESF) to manage and administer this grant. Moffatt & Nichol, a consulting firm, was selected to provide engineering and environmental consulting services to develop a Parsons Slough Restoration Plan. A technical advisory team, the Parsons Slough Restoration Team (PRT), was assembled from existing members of the Tidal Wetland Project, and assisted SCC and ESNERR/ESF project managers in developing plan goals and objectives, and overseeing and reviewing the consultants' work. The PRT, the lead consultants, and members of the Tidal Wetland Project's Strategic Planning Team and Science Panel worked together to discuss and decide key planning decisions regarding restoration alternatives.

Major alternatives were identified and developed, which is discussed in detail in Chapter 3. Following review by the PRT, alternatives were identified that advanced all of the project goals, but the costs of these alternatives were high compared to other potential restoration projects in the estuary. In December 2008 the alternatives were presented to the Strategic Planning Team and Science Panel of the Elkhorn Slough Tidal Wetland Project. At that meeting, the group called for advancing at least Goals 2 and 3 (restore estuarine processes while preserving high quality existing habitat) if achieving Goal 1 (salt marsh restoration in Parsons Slough) was infeasible in the near term due to cost. That guidance led to a follow-up investigation and ultimately to the identification of the Parsons Slough Sill alternative. That alternative was recommended by a joint meeting of the Strategic Planning Team and Science Panel in June 2009.

1.4. Responsible Parties

Development of the Parsons Restoration Plan was overseen by ESNERR, ESF, and SCC staff, and the engineering design was led by the consulting teams of *Moffatt and Nichol* and *Wetlands and Water Resources*.

A technical advisory team provided guidance. Members included

- Trish Chapman (Coastal Conservancy)
- Ross Clark and Katie Morange (Coastal Commission)
- Jacob Martin and Mary Root (US Fish and Wildlife Service)
- Suzanne Marr, Cheryl McGovern, Melissa Scianni (US EPA)
- Jim Oakden (Moss Landing Marine Labs)
- Becky Suarez (ESNERR)
- Eric Van Dyke (ESNERR)
- Peter Von Langen (Regional Water Quality Control Board)
- Kerstin Wasson (ESNERR)
- Lisa Windham Myers (US Geological Survey)
- Andrea Woolfolk (ESNERR)

Project coordination and document preparation was conducted by ESNERR staff including Bryan Largay, Andrea Woolfolk, Barb Peichel, Erin McCarthy, Monique Fountain, Quinn Labadie and Kevin Fisher.

The proposed Parsons Slough Restoration site is located within ESNERR's boundaries. ESNERR is owned and managed by the California Department of Fish and Game and administered by the National Oceanic and Atmospheric Administration.

1.5. Plan Components

The Parsons Restoration Plan includes the following components:

- An assessment of existing conditions (Chapter 2);
- Analysis of several restoration alternatives and evaluation of options for sediment additions to the site (Chapter 3);
- Formulation of a restoration plan document to provide specific suggestions for the next steps (Chapter 4).

1.6. References

Elkhorn Slough Tidal Wetland Project Team, 2007. Elkhorn Slough Tidal Wetland Strategic Plan. A report describing Elkhorn Slough's estuarine habitats, main impacts, and broad conservation and restoration recommendations. 100 pp.

Philip Williams and Associates, Ltd., H.T. Harvey & Associates, 2nd Nature, E. Thornton, and S. Monismith, 2008. Hydrodynamic Modeling and Morphologic Projections of Large-Scale Restoration Actions: Final Report. June 6, 2008.

CHAPTER 2

EXISTING CONDITIONS

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

EXISTING CONDITIONS

2.1. Chapter Summary

Available data were reviewed to characterize existing site conditions at the Parsons Slough Complex and to identify any data gaps. Anthropogenic features exist at the site posing potential constraints including two bridges, levees, culverts, overhead power lines and support towers. The site is mainly in public ownership with private property ownership at the most distant portions of two of the Five Fingers, so restoration planning should consider possible constraints of infrastructure and ownership.

Elevations of the marsh plain are approximately 2 to 3 feet (0.6 to 0.9 meters) below those needed for salt marsh vegetation. Tidal conditions are full tidal and lag times are minimal, except at Whistlestop Lagoon which is muted and lags several hours behind the tide at the Union Pacific Railroad (UPRR) bridge. The tidal prism of the Parsons Complex was between 60 to 85 million cubic feet (1.7 and 2.4 million cubic meters) in 2002, up from 49 cubic feet (1.4 million cubic meters) in 1987. These volumes are 21% and 37% of the total tidal prism of Elkhorn Slough. Tidal flow velocities at the UPRR bridge are approximately 5.6 feet per second (1.7 meters per second) on ebbing tides and 4.9 feet per second (1.5 meters per second) during flooding tides. These velocities are sufficient to erode sediments from the channel.

Vegetated salt marsh establishes at appropriate elevation ranges relative to tidal elevations. Modifying the tides would result in modification to habitat elevations. Sea level rise throughout the future is estimated to be at least 2.2 feet per century (7 mm per year) by 2050 or more with continued acceleration. The sea level in 2050 is projected to be 0.9 feet (0.27 meters) above the level in 1990. This trend needs to be considered in designs for restoration alternatives.

Long Valley contributes relatively small freshwater volumes over time directly to the Parsons Complex having a minor and temporary effect on water quality. Water quality is relatively good compared to other areas of Elkhorn Slough and is typical of that for saltwater wetlands in populated and agricultural areas. Periods of low dissolved oxygen occur in summer and fall seasons. These conditions are short-term and stress the habitat causing a seasonal constraint.

The ecology at Parsons is mainly high quality mudflat and channels. These areas support invertebrates and fishes as a prey base for larger predators, and serve as a nursery for sharks, rays, and juvenile fish. Vegetated intertidal habitat is sparse, degrading, eroding, and of poor quality. Continuing erosion would widen and deepen the channels at the expense of mudflat, and would degrade the habitat function of the channels and mudflat as has happened elsewhere in Elkhorn Slough.

Existing sediments are a thick layer of soft silts in areas sampled near the main tidal channel that do not possess contaminants. A thick layer of sand exists deep below existing ground. The site has subsided due to possible head-cutting of the main entrance channel, tidal scour from increasing tidal prism, residual effects of former diking/draining/farming, and reduced inputs of sediment from the watershed. This trend is projected to continue over time.

Data gaps exist and should be filled for final engineering including:

1. Bathymetric surveys of Whistlestop Lagoon;
2. Bathymetry of all subtidal channel areas including the channel under the UPRR bridge should occur again by 2015 to record changes from existing surveys to monitor bed scour;
3. Tidal current velocities and profile under the UPRR bridge to assess scour;
4. Updated estimate of the tidal prism of the Parsons Complex; and
5. Geotechnical investigation of the stability of the levee at Whistlestop Lagoon.

2.2. Introduction

The regional vicinity and general location of the site are shown in Figure 2-1. The Parsons Complex (including Parsons Slough, Five Fingers, South Marsh, Whistlestop Lagoon, and Rookery Lagoon) is located on the southeastern side of Elkhorn Slough as shown in Figure 2-2. Elkhorn Slough is a 2,440-acre wetland complex located on the edge of Monterey Bay, midway between Santa Cruz and Monterey. A portion of the Complex has been designated as a National Estuarine Research Reserve. The entire Parsons Complex is approximately 465 acres in size and the main areas are dominated by mudflat with subtidal creeks, fringing tidal marsh, and created tidal marsh islands. The Parsons Complex was historically a mix of salt marsh, brackish marsh, and transitional freshwater habitats but much of the vegetated salt marsh cover has changed to mudflat. Figure 2-3 shows the habitat distribution at the Parsons Complex in 1872 and in 2007, and clearly indicates significant change has occurred. The Project Site is shown in Figure 2-4. It includes approximately 161 acres of South Marsh and 304 acres of Parsons Slough and the Five Fingers area, all located east of the Union Pacific Railroad line.

2.2.1. Project Background

The Elkhorn Slough estuary contains California's second largest contiguous area of salt marsh and includes the Parsons Complex. The greater Elkhorn Slough area, including the Parsons Complex, is experiencing rapid salt marsh loss and degradation. The Tidal Wetland Project (TWP) planning effort is to evaluate erosion at Elkhorn Slough and develop restoration and management strategies. Through this process, experts from multiple disciplines agreed that without intervention, excessive erosion would continue widening the tidal channels and converting salt marsh to mudflat. This would result in a significant loss of habitat function and decrease in estuarine biodiversity.

Figure 2-1 – Regional Vicinity Map

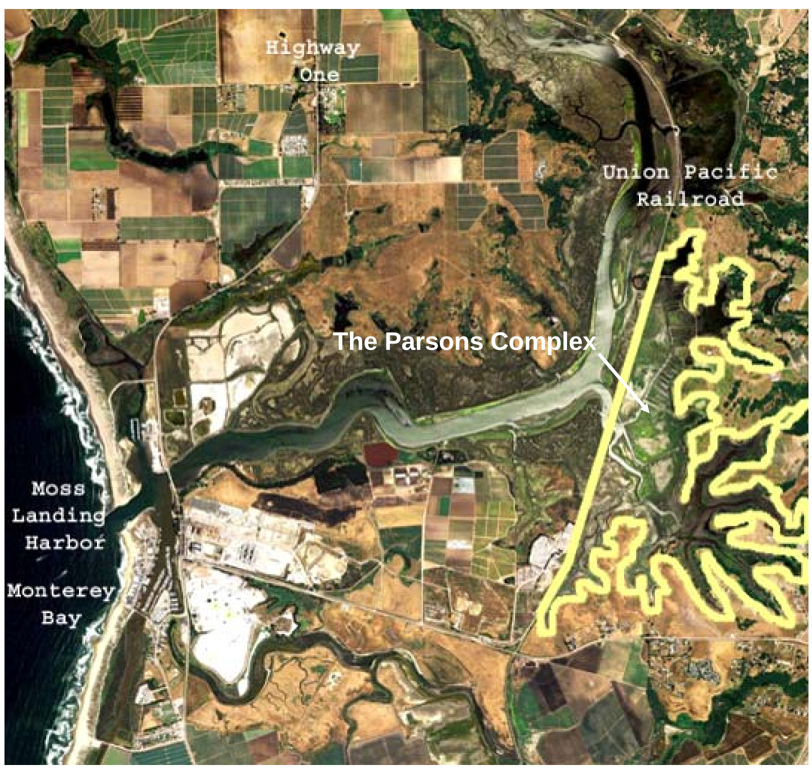


Figure 2-2 – The Project Location

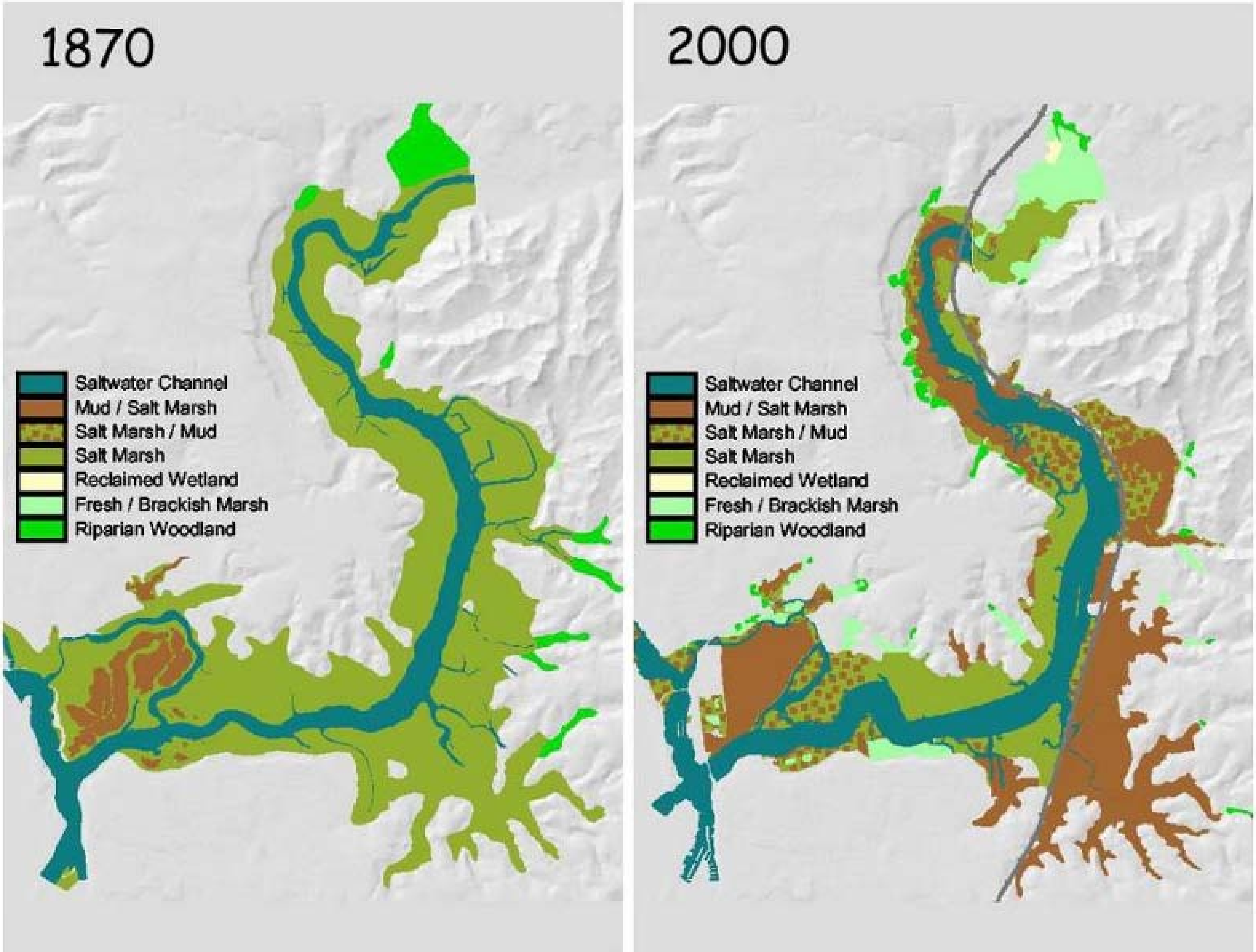


Figure 2-3 – Habitats at the Parsons Complex in 1870 and 2000 (Van Dyke and Wasson 2005)

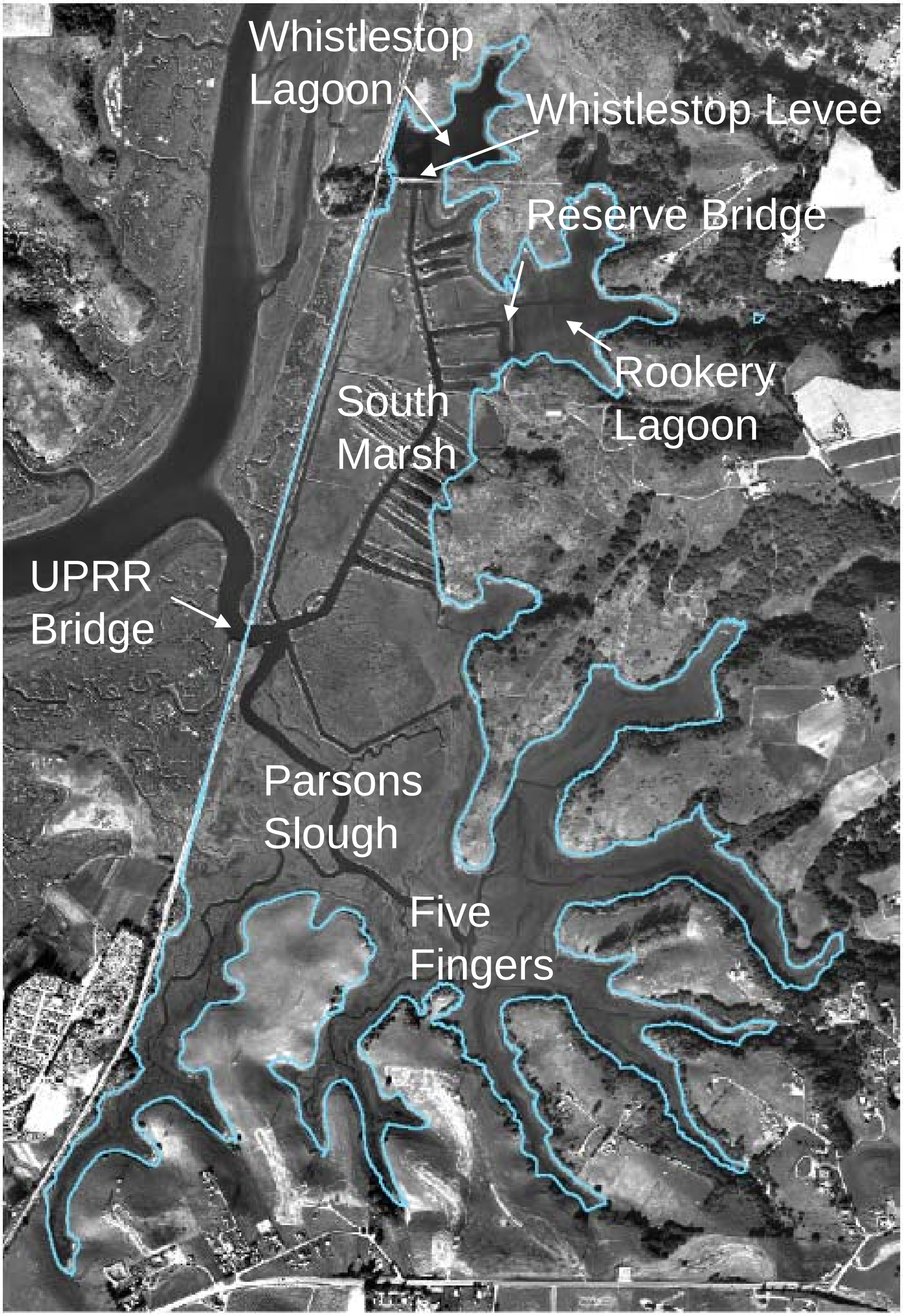


Figure 2-4 – The Parsons Complex Project Site

Several projects to address the problem were identified. Restoration of the Parsons Complex was selected as the highest priority project because significant habitat improvements can be achieved within the Complex, while also potentially achieving benefits throughout the entire Elkhorn Slough ecosystem. The Parsons Slough Complex Wetland Restoration Plan evaluates tidal marsh restoration alternatives for the Parsons Complex including actions to reduce the tidal prism in the area and/or add sediment to rebuild marsh elevations.

2.2.2. Site History

This brief site history is taken from Elkhorn Slough planning documents and borrowed from the website http://www.elkhornslough.org/tidalwetland/twmap06.htm. The Elkhorn Slough estuary, containing California's second largest tract of salt marsh, is currently facing unprecedented rates of tidal wetland loss and degradation. Over the past 150 years, human actions have altered the tidal, freshwater, and sediment processes which are essential to support and sustain Elkhorn Slough's estuarine habitats. Fifty percent of the tidal salt marsh in Elkhorn Slough has been lost in the past 70 years. This habitat loss is a result of past diking and draining, increased tidal flooding which "drowns" the vegetation, and bank erosion which causes the marsh to collapse into the channel.

Accelerating bank and channel erosion in Elkhorn Slough is deepening and widening tidal creeks, causing salt marshes to collapse into the channel, and eroding soft sediments that provide important habitat for invertebrates from channel beds and mudflats. Habitat functions for estuarine fish, shorebirds, and salt marsh are rapidly deteriorating. Increased duration and/or frequency of tidal flooding of marshes from a larger tidal prism are likely causing plants to "drown" in central areas of the marsh. Based on current knowledge, the accelerated rates of tidal erosion and marsh drowning are largely due to the combined effects of construction of a harbor in 1947 which enlarged the estuarine mouth by five times its size and has caused the tidal prism to more than double since that time, and of re-routing of the Salinas and Pajaro Rivers thus decreasing the sediment supply. The subsidence of marsh areas, the loss of riverine sediment inputs, and sea level rise may all likely contribute to marsh drowning. It is predicted that the current dramatic rates of marsh loss and tidal habitat degradation in Elkhorn Slough will continue in the near future if no restoration actions are taken. The predicted changes will cause severe habitat impacts by eroding the channel, tidal creeks, and mudflats, causing marsh plants to die, and threaten public and private property.

The Parsons Complex was historically dominated by tidal salt marsh and tidal creeks. In 1872, a railroad was built along the western side of this area and this railroad embankment blocked off the connections of about six tidal creeks and significantly altered the tidal exchange to the site. Railroad bridges were constructed over two of the main tidal creeks (mouth of the Parsons Complex and just south of Hummingbird Island) allowing these connections to remain open. A long bridge owned by the UPRR presently exists at the entrance to the Parsons Complex.

In 1902, a group of San Francisco businessmen purchased portions of the Parsons Complex and started the Empire Gun Club. Beginning in 1903, a number of large, artificial freshwater ponds for waterfowl hunting were created by constructing earthen levees around marsh areas to exclude tidal water and impounding freshwater runoff or piping in freshwater from nearby springs. In the 1920s, J. Henry Meyer acquired the Empire Club's property and it became part of Meyer's Elkhorn Dairy. By 1949, a levee had been constructed to exclude tidal flow and create pasture land in the South Marsh. This diking effectively blocked one of the two remaining tidal creeks to South Marsh just south of Hummingbird Island and separated South Marsh from Parsons Slough. Another levee, constructed across the mouth of the Parsons Complex between 1949 and 1956, effectively removed the remaining major tidal creek and marsh areas from tidal exchange. The entirety of the Parsons Complex was removed from tidal exchange by 1956 and large areas were cleared, leveled, and drained for pastureland. The combination of diking and draining of the salt marsh areas in the Parsons Complex caused the marsh sediments to dry out, compact, decompose, and subside by several feet.

In 1980, portions of Elkhorn Slough, including the majority of the Parsons Complex, were purchased and designated as a National Estuarine Sanctuary, which later became the Elkhorn Slough National Estuarine Research Reserve (ESNERR). Soon after, a wetland restoration project was initiated in South Marsh. During the winter of 1982-1983, before the project was completed, a levee breached near the mouth of the Parsons Complex during a storm event, allowing tidal waters to enter the Complex. The levee to South Marsh was temporarily rebuilt, water was pumped out to finish the creation of habitat islands and tidal channels for the South Marsh restoration project, and then the levee was intentionally breached restoring full tidal exchange to the complex in the fall of 1983.

Today, due to the increased tidal energy in the system, even these recently restored marsh habitat islands are deteriorating. The Parsons Complex now accounts for approximately 30% of the tidal prism in Elkhorn Slough. The increase in Elkhorn Slough's tidal prism has accelerated tidal marsh loss and habitat degradation throughout the system from tidal erosion of the channel, creeks, mudflats, and marsh banks and tidal flooding of interior marsh areas.

The ESNERR is presently owned and managed by the California Department of Fish and Game (CDFG) and is administered by the National Oceanic and Atmospheric Administration (NOAA).

Table 1 below provides a summary of actions at the Parsons Complex.

Table 2-1 – Timeline of Project Site History and Changes

Physical Actions/Changes	Year	Effect(s)/Conditions
Pristine Conditions (minimal human interference)	Pre-1770	Natural distribution of salt and brackish marshes, and freshwater-influenced habitats
Railroad levee constructed	1872	Tidal conveyance limited to two channels (the main one and one just south of Hummingbird Island)
Duck ponds installed	1903 - 1913	Reduced salt marsh and tidal exchange and prism throughout; portions of South Marsh, and 4 of the 5 fingers diked off for ponds
Salinas River controlled	1909	Reduced sediment influx
Significant Groundwater Pumping for Agriculture	1930's and 1940's	Seawater intrusion into the Salinas Valley aquifer (Gordon 1996)
Installation of Moss Landing Harbor and relocation of the ocean inlet	1947	Increased tidal prism and modified tidal elevations (increased the tidal range)
Reclamation of South Marsh for cattle pasture	1949	Diking, draining, and compacting the surface
Conversion to pastureland	1956	Levee and control structure have been installed in Parsons Slough, just east of the railroad bridge, eliminating tidal influence, from the rest of Parsons Complex. Surface subsidence by approximately 2 feet
Continued Significant Pumping of Groundwater for Agriculture	1967	Seawater intrusion north of lower Elkhorn Slough and lower Pajaro Valley (Gordon 1996)
Levee breaches by El Nino storms	1980 to 1982/83	4 of 6 fingers in Parsons reconnected to tidal influence
South Marsh Restoration Project	1983	South Marsh enhanced over 161 acres in north end

2.3. Existing Conditions

Information of existing site conditions is presented within this section. The information is intended to address all possible aspects of future restoration on this site.

2.3.1. Project Area Configuration

Several manmade structures exist within the Parsons Complex that present constraints to restoration. They consist of the UPRR bridge, a smaller pedestrian bridge at the ESNERR (the Reserve), levees, and several culverts described below. Elevations and dimensions throughout this report are expressed in feet, with meters also provided in parentheses. Excluded from this restoration planning effort is former estuarine habitat that now consists of impounded freshwater areas. Restoring tidal exchange to the Barn Ponds, Five Fingers Pond, Rookery Ponds, and Cattail Ponds is not included in the Parsons restoration vision. Current land management is committed to maintaining these as freshwater because of use by listed amphibians.

2.3.1.1. UPRR Bridge

Union Pacific Railroad (UPRR) owns and maintains a large bridge at the entrance to the Parsons Complex. Figure 2-5 shows the bridge in a photograph and scanned design section, respectively. This bridge is one of the primary constraints to restoration of the Parsons Complex because it dictates the position, maximum dimensions and shape of the entrance channel cross-section. As discussed in the Geomorphology section of this report, the channel cross-section is protected along the banks by the bridge abutments. Therefore any enlarging due to increasing tidal prism is done by deepening, so the channel essentially became a narrow, deep gorge that results in head-cutting of the centerline upstream into the Parsons Complex. Restoration approaches should address this constraint. A brief description of the structure follows.

The original timber bridge was installed in 1872, replaced in 1946, and then replaced again with a new one in 2003. The existing bridge is a 165-foot-long (50-meter-long) concrete slab girder bridge with new concrete abutments set just inboard of the previous abutments to not expand the channel. The original concrete abutments remain in place. Sheetpiles were driven between the old and new abutments.

Support piles are 24-inch (60 millimeter) diameter steel encased on concrete that extend down approximately 100 feet (30 meters) below the rail line. The channel width under the bridge is approximately 150 feet (45 meters) from bridge diagrams. Ten rows (bents) of piles exist spaced evenly across the channel cross-section at distances of 9 to 14 feet (3 to 4 meters) apart (Largay 2007). Each row of piles consists of 3 piles oriented along the path of flow in the channel. Thirty piles exist within the channel cross-section. The bridge clears high tide by several feet. The channel under the bridge is up to 12 to 15 feet (4 to 5 meters) deep in its deepest point (Sea Engineering 2006). More recent measurements show an average depth of 14 feet through the cross-section (Ron Eby, Personal Communication 2007). The bridge constricts flow and induces channel scour.

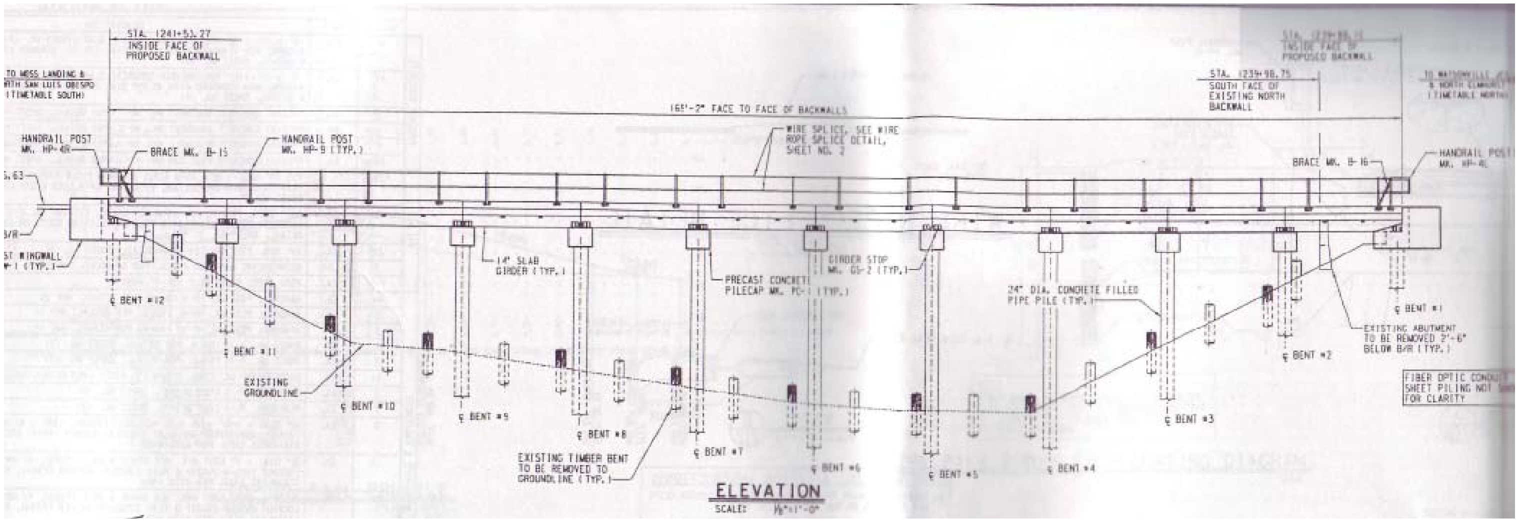


Figure 2-5 – Photograph and Design Cross-Section of the UPRR Bridge

Apparently rip-rap exists under the bridge within the channel bed to provide scour protection (Kleinfelder 2002). The extent of the rip-rap, its condition, and its effectiveness at armoring the bed are unknown. The geotechnical engineering investigation for the new bridge recommended a survey of the lateral and vertical extent of the rip-rap in the channel but this survey has not been available and the status of the survey is not known. Kleinfelder (2002) notes that the stone are 3 feet (1 meter) in diameter or less, and has been delivered in forty 50-cubic yard capacity rail cars over time. That equates to approximately 2,000 cubic yards (54,000 cubic feet or 1,530 cubic meters) of stone placed somewhere underneath the bridge within the channel.

2.3.1.2. Culverts

There are three culverts within the levee between South Marsh and Whistlestop Lagoon that connect the two basins. These culverts consist of the following:

- One 36-inch (1-meter) diameter corrugated metal pipe that conveys most of the tidal flow to and from the lagoon. Elevations of the culvert bottom (referred to as the invert) slope from 2.2 feet (0.7 meters) (National American Vertical Datum (NAVD) at the upstream end (in Whistlestop Lagoon) to 1.2 feet (0.4 meters) NAVD at the downstream end (at South Marsh) for a total vertical drop of 1 foot (0.3 meters) over a distance of approximately 40 feet (12 meters), for a slope of 1:40 (vertical to horizontal dimensions or V:H). The upstream pipe elevation is perched above the low tide in South Marsh so it causes the low tide in Whistlestop Lagoon to remain higher than that in South Marsh thereby restricting the tide range;
- One 24-inch (0.6 meter) diameter high density polyethylene pipe with a corrugated interior, with the elevations of the culvert invert sloping from 1.4 feet (0.4 meters) NAVD at the upstream end to 0.5 feet (0.15 meters) NAVD at the downstream end for a total vertical drop of nearly 1 foot (0.3 meters) over a distance of approximately 40 feet (12 meters) for a slope of 1:40 (V:H). The upstream end of this pipe is also perched above the lower low tide, but low tide elevations are influenced more by the larger pipe that is perched higher; and
- One 24-inch (0.6 meter) corrugated plastic pipe with a smooth interior that has failed and conveys no flow.

Thus, two pipes provide tidal flow to Whistlestop Lagoon from South Marsh. Both pipes are partially restricted with biofouling, or marine growth, within the pipe. The 36-inch pipe has approximately 2 to 7 inches (5 to 18 centimeters) of biofouling (muscles and sponges) on its interior walls, while the 24-inch pipe has approximately 6 inches (15 centimeters) of biofouling (muscles) along its interior walls (Largay 2007). Thus the effective cross-sectional area of each pipe is reduced by approximately 40% and 50%, respectively. Tides within Whistlestop Lagoon are significantly muted as a result of restrictions in these connections and the perched elevation of the pipes for a tidal range of approximately 1.5 feet (0.5 meters) (Wasson 2007). Observations at culverts at other wetlands show that biofouling typically reaches a critical maximum and then does not expand further. Depending on the ages of these culverts, biofouling may be at a maximum and not be expected increase substantially in the future.

Pertinent observations by Largay (2007) indicate the following:

- The levee is periodically overtopped, is deforming and is thus placing stress on the 36-inch culvert. Prolonged stress placed on the 36-inch corrugated metal pipe may result in its failure in the future and threaten the long-term condition of tidal flow to this site. This larger pipe conveys more flow than the smaller pipe and is therefore important to maintain.
- The 24-inch pipe is leaking into the levee towards the downstream end of the pipe.
- Substantial deformation of the culverts and a concave up profile is evident, probably caused by differential settling of the levee. The concave up profile reduces flow rates through the culverts. This may increase the likelihood of levee overtopping and instability.

The culverts are shown in Figure 2-6, images A, B and C.

2.3.1.3. Levees

Levees are located along the western perimeter of the Parsons Complex where the UPRR railroad line exists, between Whistlestop Lagoon and South Marsh, and between the Rookery Lagoon and South Marsh. All three are earthen levees that contain the areal extent of the full tidal basin within the Parsons Complex.

2.3.1.3.1. Whistlestop Levee

The relatively short levee between Whistlestop Lagoon and South Marsh is approximately 350 feet (108 meters) long as measured using the Google Earth program. The elevation of the levee is approximately 8.0 feet (2.4 meters) above NAVD and it is observed to be settling, or sinking, allowing overtopping by high tides. Overtopping of the levee could eventually cause levee failure if it were weakened sufficiently along its crest or walls. Failure of this levee would cause an increase in the tidal prism of the entire hydraulic system of the Parsons Complex.

2.3.1.3.2. UPRR Levee

The levee separating the Parsons Complex from Elkhorn Slough was installed in the 1872 by the railroad. Dimensions of the levee are approximately 6,800 feet (2,073 meters) long or 1.3 miles in length, 40 to 50 feet- (12- to 15 meters-) wide at the base, and reaches an elevation of approximately 6 to 8 feet (1.8 to 2.4 meters) above NAVD. This levee is slightly higher than the highest tides of the year throughout most of its length. A lower reach of the levee exists adjacent to South Marsh where the levee is inundated at the highest tides. The location of this “saddle” in the levee is approximately 1,500 feet (457 meters) north of the UPRR bridge and it is nearly 1,150 feet long (350 meters long). This location appears to be in approximately the same position of former Slough channels and may be the cause of settling, as historic marsh soils settle under the weight of the levee fill and rail loads.

2.3.1.3.3. Rookery Lagoon Levee

A levee separates South Marsh from the Rookery Lagoon. This feature is approximately 550 feet long (168 meters) and 20 feet (6 meters) wide at its base. The levee is supported by a timber pile wall along its west face.

2.3.1.4. Reserve Pedestrian Bridge

The Rookery Lagoon of the ESNERR is connected to South Marsh by a bridge opening through the levee. The bridge is approximately 50 feet (15 meters) long and is constructed of wood, with wooden abutments. This bridge was replaced in the early 2000s and now is supported by two steel I-beams (A. Woolfolk, Personal Communication, 2007). Figure 2-7, images A and B show the Reserve Pedestrian bridge and a portion of the levee.

2.3.2. Utilities

Utility lines and infrastructure within the project area are limited to overhead power lines and a buried fiber optic cable line. Five overhead power lines lie over portions of the project site. Figure 2-8 shows the locations of poles that support power lines within the Parsons Complex. All power lines enter the site from the southwest corner originating from the local power plant and trend north, northeast, and east, respectively through the area.

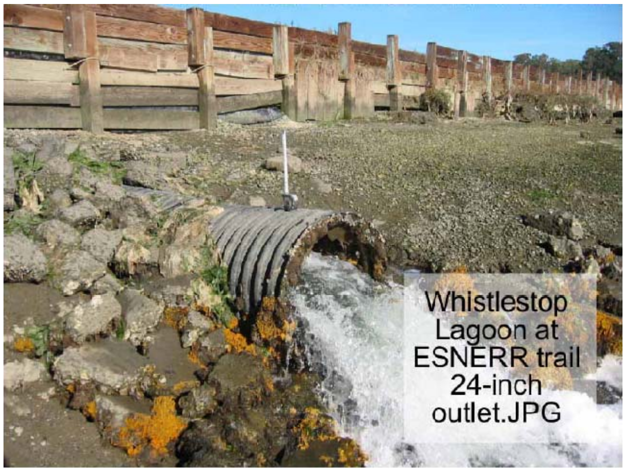
One line lies across the base of the five fingers and extends to the north along the eastern portion of South Marsh. Two more lines extend northeast across four of the five fingers, and two other lines extend east across the southernmost tip of the western finger. All are high voltage lines that should be avoided for any project work if possible.

A fiber optic cable line exists within the UPRR rail corridor right of way buried within the levee along the east side of the track. No details were found with regards to this line.

2.3.3. Property Ownership and Boundaries

The majority of the Parsons Complex (except for a few tips of five fingers) is owned and managed by the California Department of Fish and Game as part of the Elkhorn Slough National Estuarine Research Reserve. Figure 2-9 shows land ownership within the Parsons Complex. Several other property owners exist at the most distant ends of two of the westernmost of the five fingers.

A. Culverts and Levee, Looking East



B. The Functioning 24-Inch Culvert

C. The 36-Inch Culvert (Top) and Non-Functional 24-Inch Culvert (Bottom)

Figure 2-6 – Culverts to Whistlestop Lagoon

Most property ownership outside of the CDFG is on the peninsulas between the fingers. However, as several other property owners exist within the water area of the two most western fingers, they may constitute a potential constraint to sediment addition alternatives that require access to and activity within these areas of the fingers.

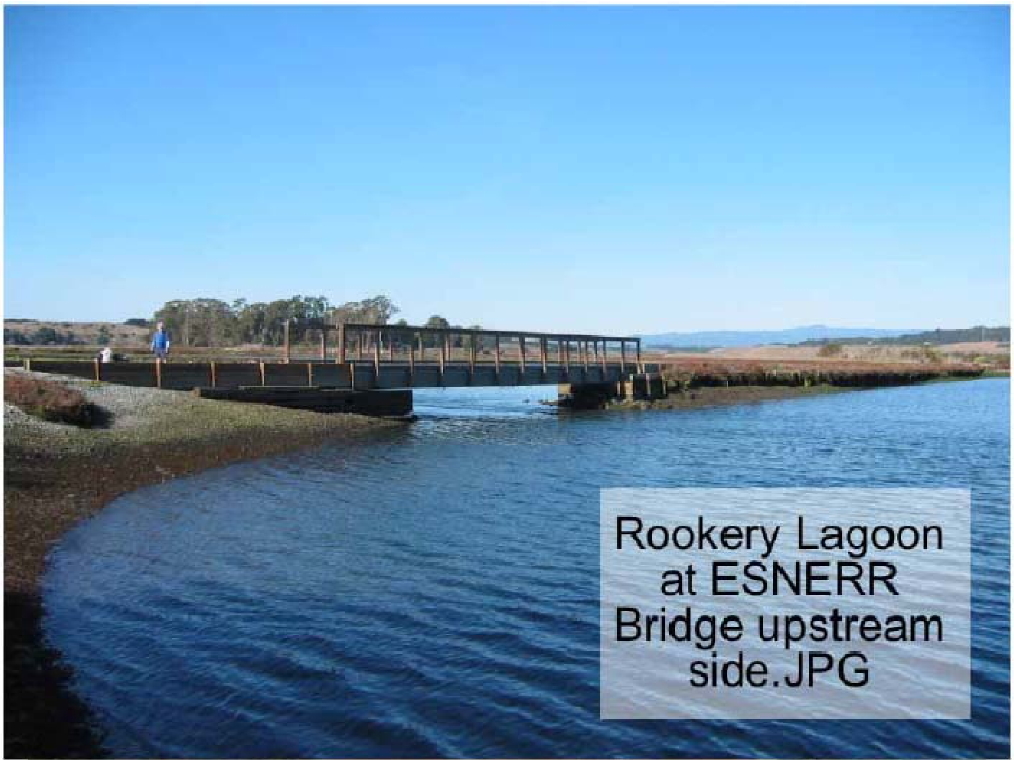
2.3.4. Topography/Bathymetry

The elevations of the marsh plain and tidal channels in the Parsons Complex are relatively low overall compared to a typical salt marsh. Topography is roughly defined as ground surface elevation above water. Bathymetry is roughly defined as ground surface elevation in submerged areas (below water). Figure 2-10 shows existing elevation contours for both exposed and submerged areas of the Parsons Complex. These data were provided by the ESNERR staff from their Geographic Information System (GIS) (E. Van Dyke, Personal Communication 2007). The values are in feet, relative to North American Vertical Datum (NAVD). The NAVD vertical datum is very similar to (0.2 feet below) Mean Lower Low Water (MLLW). The MLLW datum is the mean value of the ocean lower low tides that is the reference for tidal elevations in standard tide books or charts.

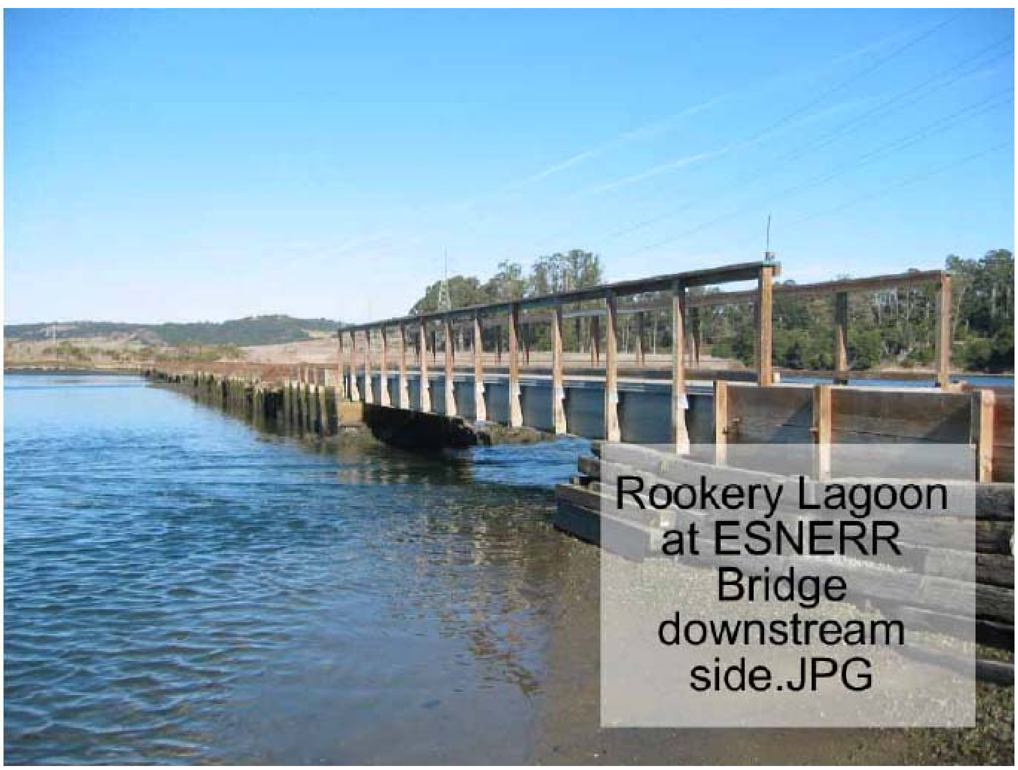
Elevations within the Parsons Complex range from a low of -19.7 feet (-6 meters) relative to NAVD in the main inlet channel just east of the UPRR bridge to a high of approximately 8 feet (+2.4 meters) NAVD along the salt marsh perimeter, and higher at upland areas outside of tidal influence. Ninety percent the area of the Parsons Complex lies between approximately 0 to +3 feet (0 and +1 meters) NAVD. These elevations are below the elevations required for growth of emergent salt marsh vegetation and are therefore indicative of subtidal or unvegetated intertidal habitat (mudflat) areas. Figure 2-11 shows the areas of the site at each elevation. These data were also provided by the ESNERR staff from their GIS (E. Van Dyke, Personal Communication 2007).

The major ramification of the existing topographic/bathymetric condition is that nearly the entire area of the Parsons Complex lies below the elevation range required to colonize and sustain vegetated salt marsh. The elevations of vegetated salt marsh in full tidal systems in California range from approximately +4.2 feet (+1.3 meters) NAVD for low marsh, up to 4.9 feet (1.5 meters) to 5.8 feet (+1.8 meters) NAVD and above for high marsh (Moffatt & Nichol 2004), depending on site conditions.

The average land elevation in the Parsons Complex has subsided by approximately 1.9 feet (0.57 meters), and is now 2.4 feet (0.70 meters) lower than what can support vegetated salt marsh habitat (ESTWPT 2007). Apart from a few constructed tidal marsh islands and fringes of tidal marsh adjacent to upland areas, this site primarily supports mudflat habitat.



A. Reserve Pedestrian Bridge Looking Northwest



B. Reserve Pedestrian Bridge Looking North

Figure 2-7 – Reserve Pedestrian Bridge at Rookery Lagoon

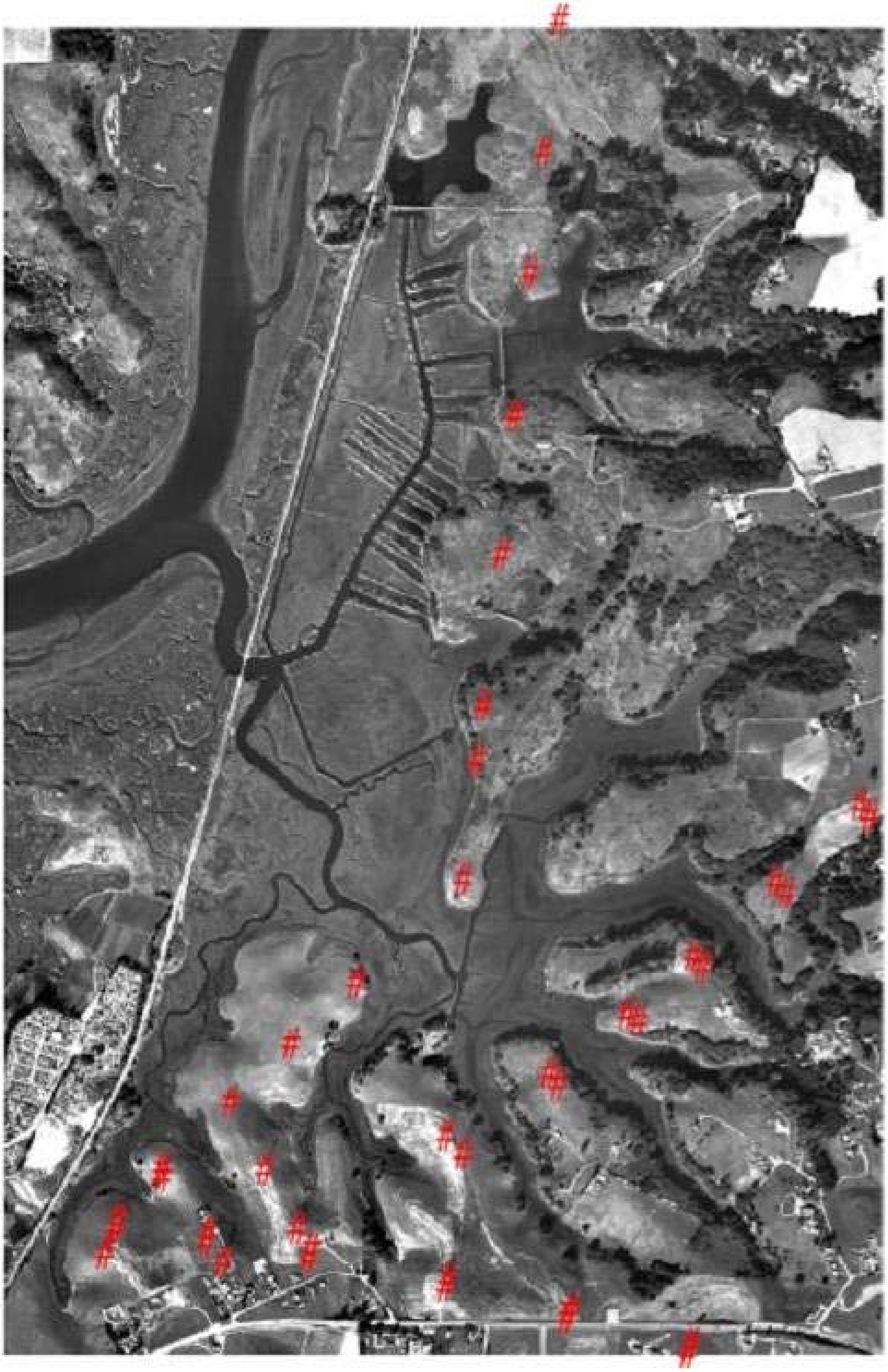


Figure 2-8 – Locations of Utility Power Poles Within the ESNERR

Figure 2-9 – Land Ownership Within the Project Area

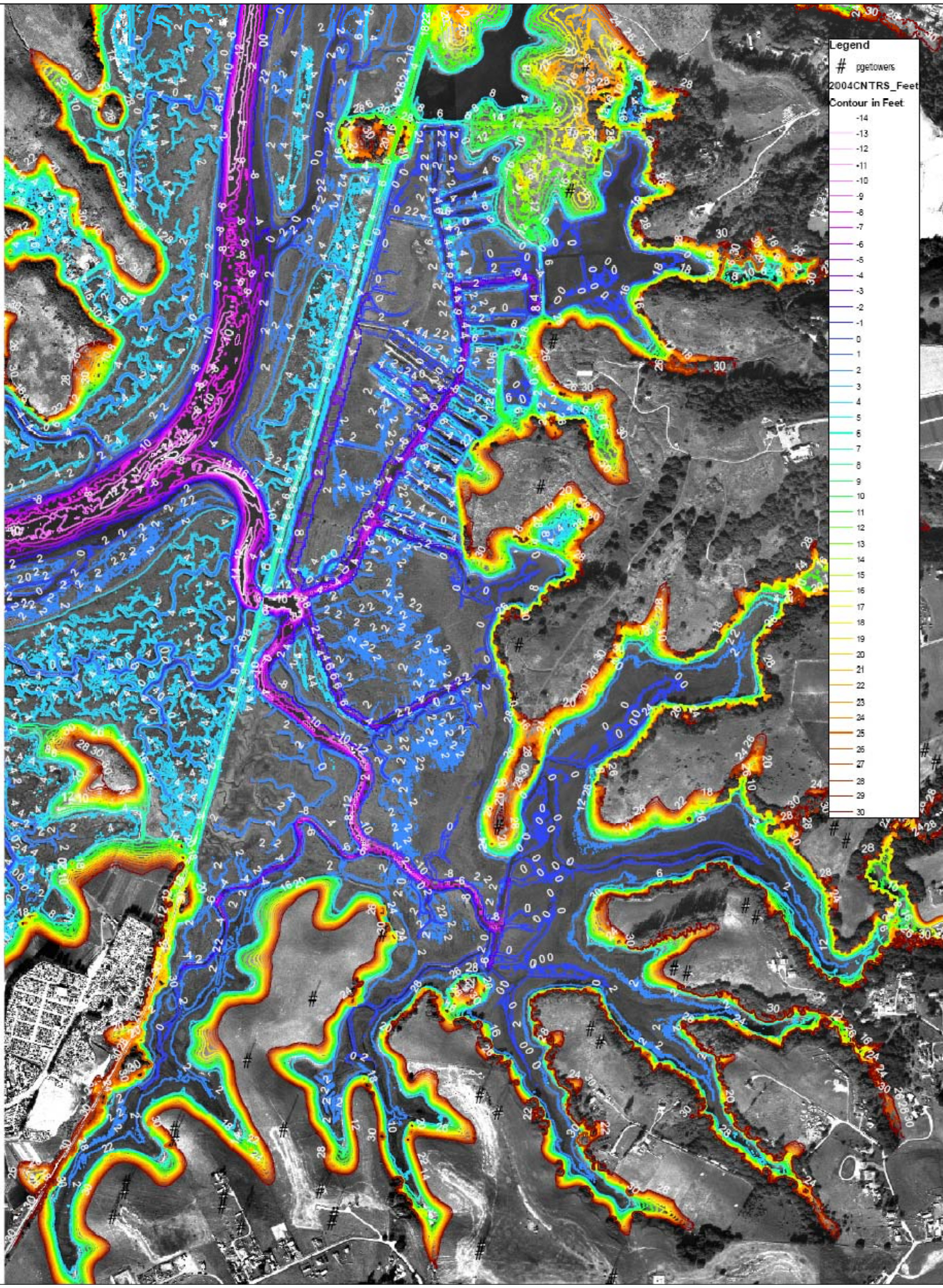


Figure 2-10 – Existing Site Topography/Bathymetry

Reasons for the existing low elevation condition include severe land subsidence that occurred during the years that the wetland was diked and drained for use as pasture, loss of sediment due to erosion that has occurred since restoration of the South Marsh and Parsons Slough area in 1983, head-cutting of the main entrance channel, and decreased natural sediment yield (although the sediment yield from the smaller local watershed to the Parsons Complex may be higher than natural rates in some instances such as at strawberry field agricultural areas, and gullies on the ESNERR) (Woolfolk, personal communication 2007). Work is still on-going to determine the sources and rates of historic and existing sedimentation. These processes are documented thoroughly in documents prepared for Elkhorn Slough (ESTWPT 2007; Caffrey et al. 2002), and at URLs developed for the site (http://www.elkhornslough.org/tidalwetland/twmap06.htm).

2.3.5. Hydrology and Hydraulics

All aspects of hydrology and hydraulics, including tidal and freshwater components, are presented herein to provide the basis for water level analyses as part of restoration planning.

2.3.5.1. Tidal Elevations, Range, and Lag Times

The Parsons Complex is largely unrestricted with regards to tidal flow with essentially no significant impedances as documented in available literature (Elkhorn Slough Tidal Wetland Project Team 2007; Sea Engineering, Inc. 2006; Philip Williams & Associates, or PWA, 2007) and data on the internet from the Land/Ocean Biogeochemical Observatory (LOBO) system (Monterey Bay Aquarium Research Institute url 2007). The only portion of the Parsons Complex that is significantly restricted to tidal flow is the site referred to as "Whistlestop" Lagoon at the north end of the main project area. Tides to and from Whistlestop Lagoon are significantly restricted by a set of culverts previously described in this report. Measuring stations for tidal data presented here are shown in Figure 2-12.

2.3.5.1.1. Tidal Elevations and Range

The range of tidal elevations within the Parsons Complex are consistent with those in the Pacific Ocean. Tides are mixed semi-diurnal with a mean daily tide range of 5.6 feet (1.7 meters) and a low-low tide following a high-high tide. The spring tide range is 8.2 feet (2.5 meters) and the neap range is 3 feet (0.9 meters) (Broenkow and Breaker 2005). The tide range in Parsons Complex is approximately the same as that of ocean as recorded by LOBO at station LO5 through a representative period in January 2007 as shown in Figure 2-13. Tides in the Parsons Complex appear to be roughly symmetrical about mean sea level and occur approximately coincident with the ocean tides.

Tidal muting exists in Whistlestop Lagoon due to culvert restrictions (Ritter et al. 2007). The tide range is approximately 1 foot (0.3 meters) centered about mean sea level as measured by ESNERR staff during a spring tide in December of 2005 (K. Wasson, Personal Communication 2007).

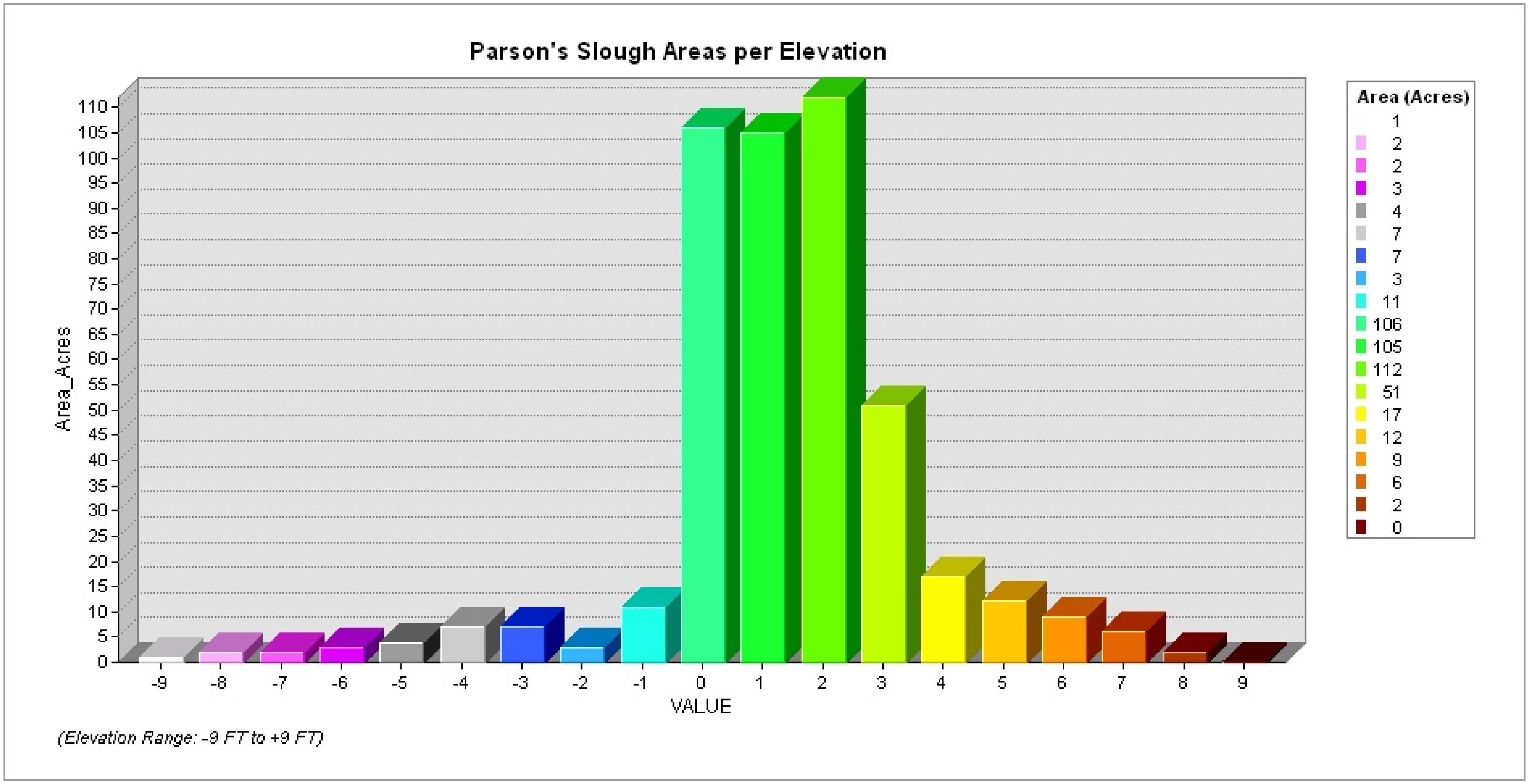


Figure 2-11 – Areas at Each Elevation Within the Parsons Complex

2.3.5.1.2. Tidal Lag Times

An insignificant time lag exists between high and low tides in the fully-tidal areas of the Parsons Complex and those in the ocean. The data in Figure 2-13 do not show a measurable time lag between the Parsons Complex and the ocean.

Some lag would be expected in more distant areas of the Parsons Complex compared to conditions at the Parsons Complex entrance channel (UPRR bridge location). According to Broenkow and Breaker (2005), the tidal range in Parsons Slough is virtually identical to that at the UPRR trestle. The occurrence of higher high water in the South Marsh area of the Parsons Complex lags only slightly behind that at the UPRR bridge by approximately 2 minutes, so an internal time lag exists within distant areas within the Parsons Complex.

A time lag exists in Whistlestop Lagoon between high and low tides compared to those in the main area of the Parsons Complex. In December 2005, during a spring tide event, ESNERR staff documented a 4 to 5 hour lag time between high and low tides at Whistlestop Lagoon and the adjacently South Marsh (K. Wasson, 2007 personal communication).

2.3.5.2. Tidal Prism

The tidal prism is defined as the volume of water passing into and out of a site over a typical tidal range and it is expressed as a volume, typically as cubic feet or cubic meters. The tidal prism at the Parsons Complex has been estimated at several points in time and using several different methods. Estimates all show increases in the tidal prism since the return of tidal flow to the Parsons Complex in 1983. Previous estimates include those by PWA (1992) for conditions in 1987, and those more recently by Broenkow and Breaker (2005) for conditions in 2002.

As relayed by Sea Surveyor (2006), PWA estimated the prism by calculating the surface area of water levels at various tidal stages in the Complex and multiplying by different tidal heights. The PWA estimate is 49.5 million cubic feet (1.4 million cubic meters) in the Parsons Complex and 233 million cubic feet (6.6 million cubic meters) within Elkhorn Slough, with the Parsons Complex constituting 21% of the overall Slough tidal prism.

Broenkow and Breaker estimated the prism at Parsons by installing a current meter in the channel near the UPRR bridge, and calculating the tidal discharge through the channel using the tidal flow velocity multiplied by the channel cross-sectional area, integrated over the duration of the tidal flood or ebb. The Broenkow and Breaker estimate is 85 million cubic feet (2.4 million cubic meters) for the Parsons Complex. They performed a similar operation for Elkhorn Slough using a current meter installed approximately 820 feet (250 meters) east of Highway 101 over a seven-hour flood tide and estimated a tidal prism of 226 million cubic feet (6.4 million cubic meters), with the Parsons Complex constituting 37.5% of the overall Slough tidal prism.

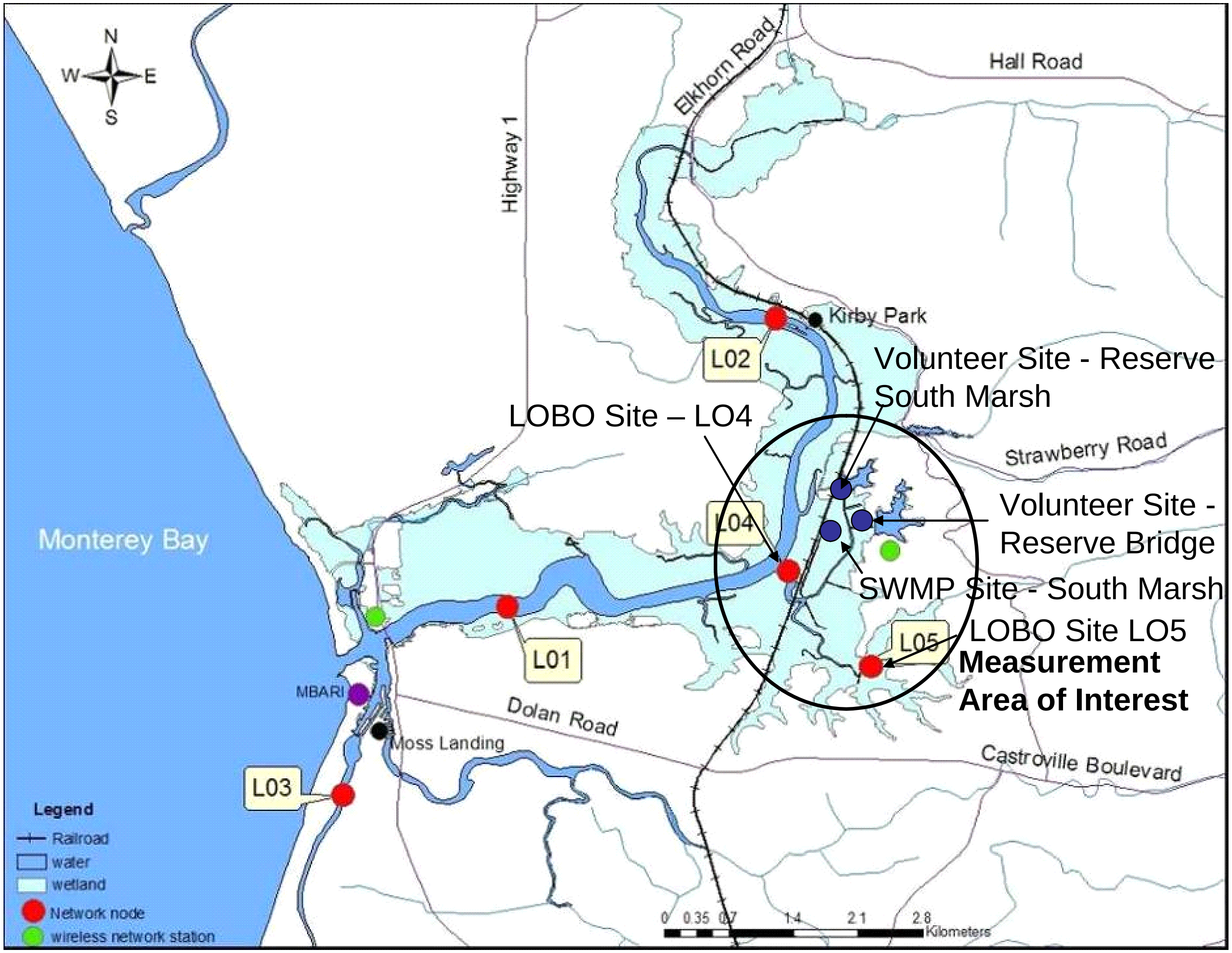


Figure 2-12 – Measuring Stations for Water Levels (Tides) and Water Quality

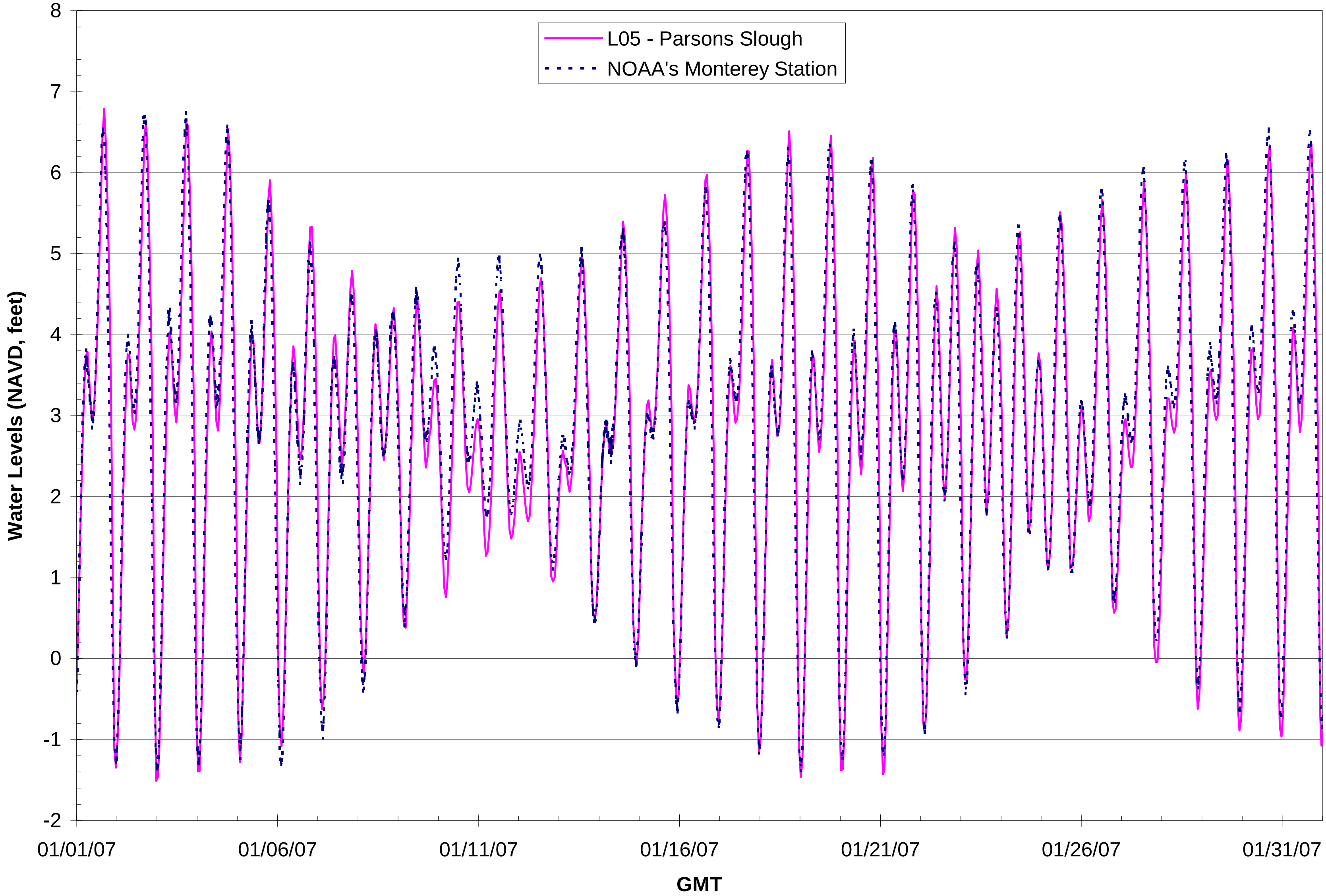


Figure 2-13 – Tides at the Parsons Complex and the Ocean

2.3.5.3. Tidal Inundation Frequency

The condition of tidal inundation frequency, or the percentage of time that a site is inundated by seawater, dictates the type of habitat that becomes established within a salt marsh. Areas of the marsh that are always inundated (100% inundation frequency) are designated as subtidal habitat. Subtidal habitat is used primarily by fish. Areas that are higher than subtidal habitat but still inundated more than 41% of the time are mudflat. Mudflat areas are inundated too often for establishment of plant life, but are home to invertebrates. Depending on conditions, areas above mudflat that are inundated between 6% to 41% of the time will generally be colonized by vegetated salt marsh. The lower areas of vegetated salt marsh that are inundated between 20% and 41% of the time may be vegetated by low marsh plant life such as cordgrass if conditions are suitable. Cordgrass has not been documented to previously exist in Elkhorn Slough so that plant type may not colonize the site. Areas that are higher than low marsh and inundated between 6% and 20% of the time are typically occupied by pickleweed and called middle to high marsh. Areas above high marsh are colonized by salt grass and other plants and referred to as transitional or upland habitats. Salt marsh habitats and associated plant life are addressed in more detail in the Ecology section of this report.

The inundation frequency curve at the Parsons Complex was created using LOBO tide data and is shown in Figure 2-14.

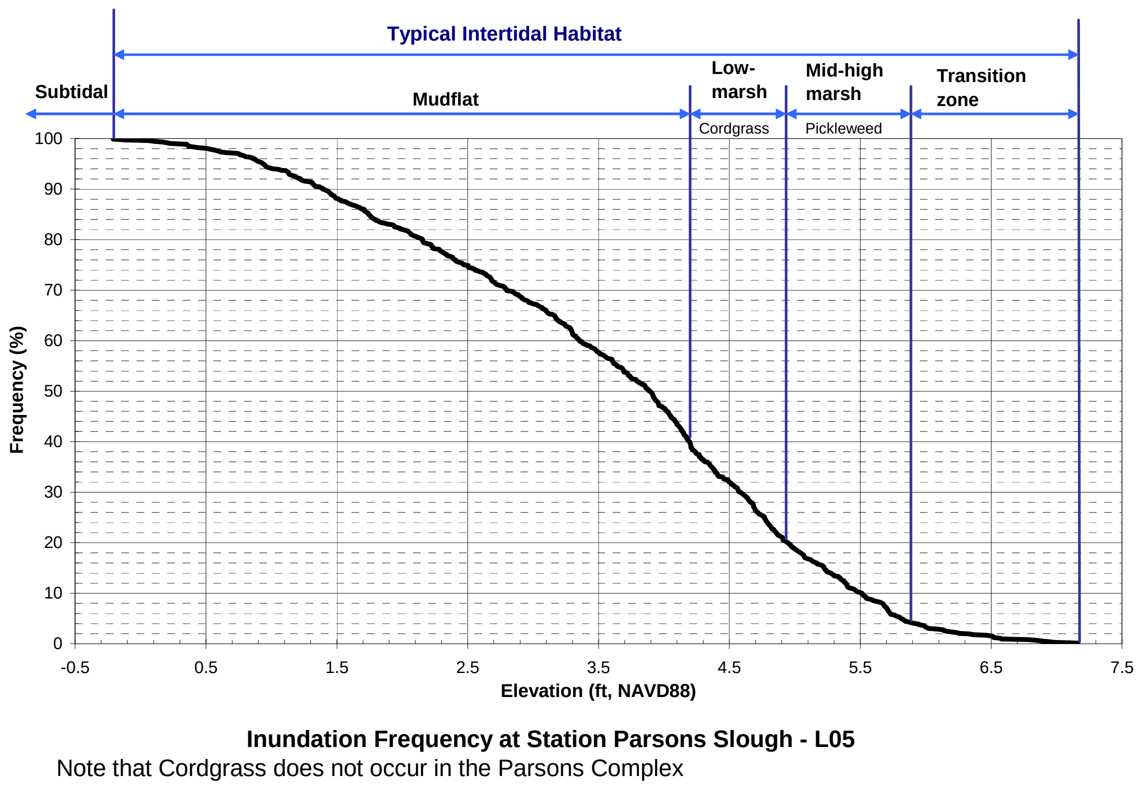


Figure 2-14 – Inundation Frequency Curve at the Parsons Complex

Salt marsh habitat could form at appropriate elevations under existing conditions if marsh plain elevations were sufficient to enable colonization. Vegetated salt marsh habitat could colonize the Parsons Complex at an elevation range of between 4.3 and 5.8 feet (1.3 meters and 1.8 meters) NAVD according to the tide data, and depending on whether attempting to colonize cordgrass is desirable. If cordgrass is not desired, then the lower end of the elevation of vegetated marsh would rise to 4.9 feet (1.5 meters). Unvegetated mudflat areas are found below 4.9 feet (1.5 meters) NAVD as cordgrass has not colonized the site and low marsh remains devoid of plant life.

2.3.5.4. Tidal Flow Velocities

Tidal flow velocities within the Parsons Complex were measured at the UPRR bridge location by several sources. Tidal flow velocities are very high at the bridge that serves as the funneling point for the entire site. Maximum flow velocities at the bridge are higher on the ebbing (outgoing) tide than the flooding (incoming) tide. Estimates were made by Wong (1989) at 5.6 feet per second (1.7 meters per second) on ebbing tides and 5.0 feet per second (1.5 meters per second) on flooding tides for conditions in 1986. More recently, Broenkow and Breaker measured maximum tidal currents at 5.6 feet per second (1.7 meters per second) on ebbing tides and 4.9 feet per second (1.5 meters per second) on flooding tides for conditions in 2002. These data indicate that tidal flow velocities have remained fairly constant from 1986 to 2002. Data do not exist for more distant areas of the Complex, but flow velocities likely drop with distance from the UPRR bridge channel to within the main Complex as the cross-sectional area of flow increases just east of the bridge and flow disperses to the various areas of the Complex.

Numerical modeling done by PWA (2007) predicts probable tidal flow velocities at the UPRR bridge on the order of 3.3 feet per second (1.0 meter per second) for ebbing tides and (1.6 feet per second (0.5 meters per second) for average flood tide conditions (not spring tides). The conditions of the modeling period were moderate tides in April 2003 recorded by Stanford.

These velocity readings for the Parsons Complex are lower than those at the Highway 1 bridge at Elkhorn Slough because the opening at the UPRR bridge conveys significantly less prism than the Highway 1 bridge opening (Sea Engineering 2006). Also for comparison, maximum tidal flow velocities in the main channel at Elkhorn Slough were measured at 2.0 to 4.9 feet per second (0.6 to 1.5 meters per second) in 2005 (ESTWPT 2007 from N. Nidzieko, personal communication).

2.3.5.5. Sea Level Rise

Research was performed to identify the probable range of sea level rise rates to use to characterize existing conditions and project future conditions. The starting-point for this review of sea level rise is the work of the Intergovernmental Panel on Climate Change (IPCC), and specifically, their latest assessment of the science of climate change modeling (IPCC 2007; Ralmstorf 2007).

Historical sea level rise at Elkhorn Slough appears similar to the global average rate of historical sea level rise. A value of 0.7 feet per century (2 mm per year) is appropriate based on measurements at San Francisco compared to those at Elkhorn Slough by NOAA (2007). Plus, an observed increase in tidal range has also occurred at San Francisco. These data suggest that the tidal range at the mouth of Elkhorn Slough may increase up to 0.1 feet (0.03 meters) in 50 years. For future sea level rise (through 2050), two plausible scenarios can be identified for the Parsons Complex:

- Likely high rate of increase: Sea level rise accelerates according to the upper limit of the *2007 IPCC Report* projections, which is similar to the lower limit of Rahmstorf's (2007) projections. The rate of sea level rise reaches about 2.2 feet per century (7 mm per year) by 2050, and continues to accelerate. The sea level in 2050 is 0.9 feet (0.27 meters) above the level in 1990.
- Highest rate of increase: Sea level rise accelerates according to the upper limit of the *2007* Rahmstorf's projections. The rate of sea level rise reaches 4.4 feet per century (13 mm per year) by 2050, and continues to accelerate. The sea level in 2050 is 1.4 feet (0.43 meters) above the level in 1990.

More rapid scenarios have been discussed in the scientific literature, particularly in the light of possible nonlinear effects such as instability of the Antarctic and Greenland Ice Sheets. However, it seems very unlikely that these will significantly increase sea level rise in a 50-year time frame. Table 2 gives intermediate values for the two scenarios for Parsons Complex. Given the scientific uncertainty, it may be more practical to use the IPPC sea level rise estimate for design of restoration projects. Any sea level rise may threaten use of the UPRR rail corridor through the site and may necessitate some type of responsive action.

Estimates of sea level rise are regularly updated with some of the latest projections provided by the State of California indicating a rate of rise of 16 inches (0.40 m) by 2050 and 55 inches (1.39 m) by 2100 (CalFed 2007).

Table 2-2 - Sea Level Rise Scenarios: Increases based on Different Rates

Year	**1990**	**2000**	**2010**	**2030**	**2050**
2007 IPPC projection (feet)	0.0	0.1	0.2	0.5	0.9
2007 Rahmstorf Projections (feet)	0.0	0.1	0.2	0.7	1.4

2.3.5.6. Storm Runoff

Storm runoff directly to the Parsons Complex is limited to that entering from the watershed immediately adjacent to the site. The largest direct freshwater tributary to the Parsons Complex is Long Valley, as shown in Figure 2-15. Long Valley yields storm runoff from a distance of 3 miles to the east. The volume of storm runoff to the Complex is only approximated here because no stream gage exists for discharge data. Based on assuming that watershed conditions of Long Valley are somewhat similar to those of the Salinas River, the estimated average annual discharge is estimated at 1.15 cubic feet per second (cfs) (0.03 cubic meters per second), compared to 17.2 cfs (0.49 cubic meters per second) for the Salinas River. The average annual runoff from Long Valley to the Parsons Complex is approximately 830 acre-feet. Long Valley contributes much lower runoff to the Complex than larger tributaries, and only has a marginal short-term effect on water quality to the Complex.

Storm runoff is also indirectly conveyed to the Parsons Complex from Elkhorn Slough, which receives runoff from Carneros Creek at the upstream end of the estuary and the old Salinas River Channel at the downstream end of the system.

According to the PWA model calibration report, from a hydraulic standpoint storm runoff to Elkhorn Slough has no significant effect (PWA 2007). Freshwater flows are small compared to tidal flow and do not alter characteristics that cause geomorphic changes, such as current velocities through the Slough (and the Parsons Complex) or water surface elevations on the marsh plain.

2.3.5.7. Groundwater

Groundwater presents a minor influence on conditions at the Parsons Complex compared to existing surface tidal flows. Groundwater was at one time more influential in determining conditions at the Parsons Complex when levels were high and springs existed at the upstream ends of some of the fingers. Land survey maps from the early 1900s show freshwater artesian springs in many tidal marsh areas of Elkhorn Slough (ESTWPT 2007). Fifty years ago, artesian wells, natural seeps, and springs were found throughout the Elkhorn Slough watershed. However, groundwater has been significantly overdrafted as first documented in the 1930s and 1940's due to an increase in irrigation of agricultural lands (MCWRA 2005). The overdraft of groundwater has caused seawater intrusion. Over the last twenty to thirty years, ocean water has steadily intruded farther inland, raising chloride concentrations in wells near Elkhorn Slough (MCWRA 2005). The existing depth to groundwater is shallow along the Slough perimeter, and deeper away from the Slough as a function of progressively increasing elevations away from the Slough. The link between Elkhorn Slough and its individual areas, and groundwater conditions needs further study (Caffrey et al. 2002).

Less groundwater and freshwater inputs occur from local watersheds to the Parsons Complex compared to historic times, particularly with modifications to both the Salinas and Pajaro Rivers that reduced the freshwater influence on Elkhorn Slough. In the early 1900s before farming became widely established within the watershed, diking within the Parsons Complex caused a local build-up of groundwater and surface freshwater elevations. This led to establishment of brackish and riparian habitats, and salt/freshwater transition areas. Subsequent lowering of the marsh plain, removal of the dikes, and restoration of the site to salt marsh caused loss of much of these habitat areas, although some isolated areas still exist along the eastern project boundary.

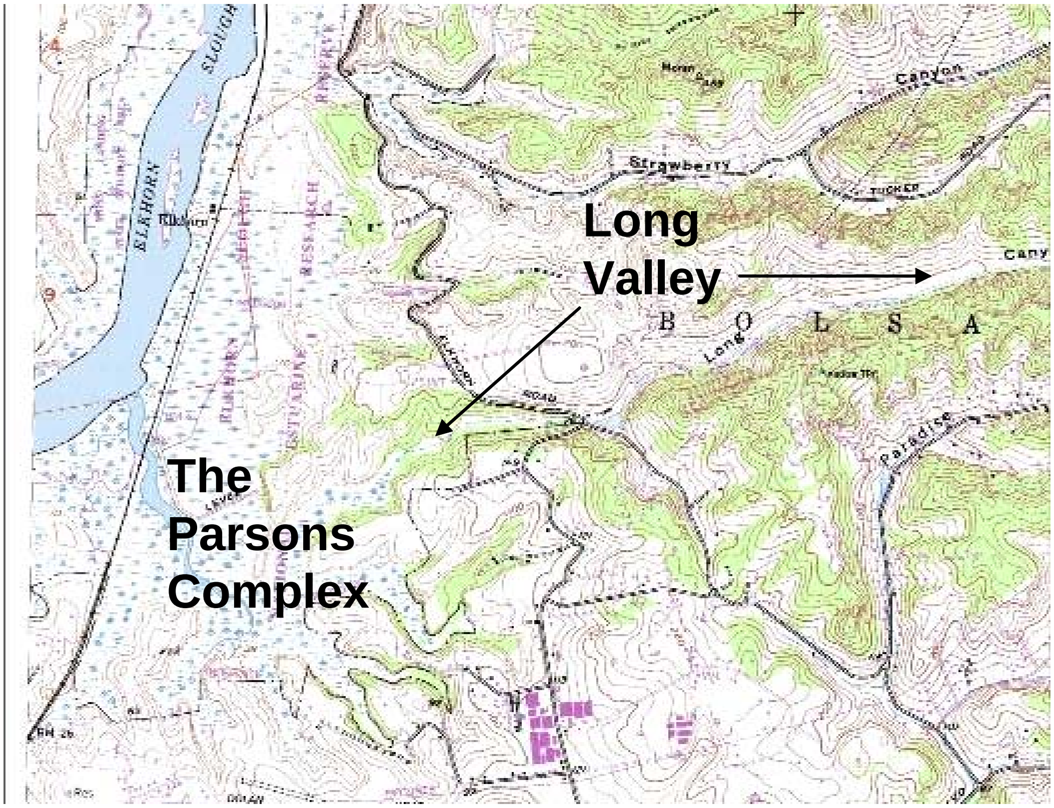


Figure 2-15 – Long Valley Location

2.3.6. Water Quality

Water quality at the Parsons Complex has been measured by the following three different programs:

1. The Federally-sponsored National Estuarine Research Reserve's (NERR) System-Wide Monitoring Program (SWMP). One automated SWMP site exists at South Marsh just upstream of the UPRR bridge and readings are taken every 30 minutes. Parameters reported include salinity, temperature, pH, dissolved oxygen, and turbidity. Data are available from January 1996 to the present and available continuously. For this effort data were considered through May 2005. These data represent a continuously collected time series - every 15 minutes for the past year, every 30 minutes for the previous 10 years. This program includes nutrients over a diurnal cycle, with 24 samples taken over a full tidal cycle, monthly for the past 4 years (along with chlorophyll).

2. The ESNERR volunteer program that records monthly readings of the same parameters measured by the NERR SWMP program. Two volunteer sites exist at the north and northeast portions of the Parsons Complex at sites called “South Marsh - the Reserve” (dike within Whistlestop Lagoon) and “the Reserve Bridge” (bridge connecting the Parsons Complex with the wetland near the Rookery Lagoon). Data are available from September 1989 to the present, but are utilized up to September 2002 for this effort.
3. The LOBO system continuously monitors water quality using a network of buoys throughout Elkhorn Slough, with one in the Parsons Complex designated as LO5. This site is a valuable data point in that it provides continuous data showing short-term temporal fluctuations in water quality, plus more detailed spatial variation between the Parsons Complex and Elkhorn Slough that may be a function of inputs specific to the Parsons Complex and lags in tidal flushing. Measurements include water depth; nitrate concentration (measured at 0.5 meter depth), salinity and temperature (at depths of 0.5 m and 2 m), oxygen concentration (at depths of 0.5 m), turbidity (at depths of 0.5 m), and Chlorophyll biomass (at depths of 0.5 m). Data have been recorded since August 2006.

Figure 2-12 shows SWMP sites, volunteer water quality monitoring sites, and the LOBO sites. Overall, water quality is relatively high in the Parsons Complex compared to other sites in Elkhorn Slough according to the literature (ESTWPT 2007; Elkhorn Slough Foundation 2002; Presentation data from the ESNERR 2007) and data provided by the sources listed above. A summary of water quality is presented below.

2.3.6.1. Turbidity

Turbidity in the Parsons Complex appears to be relatively low and isolated to certain events or seasons. Turbidity data are measured by the SWMP program, by volunteers, and the LOBO network.

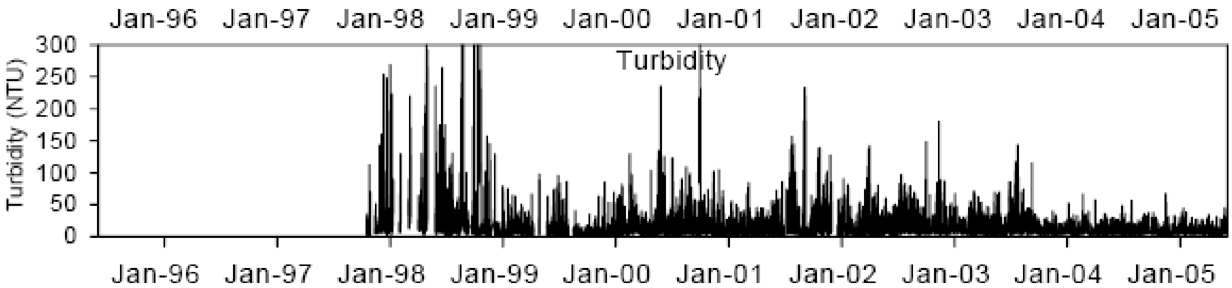
Figure 2-16 shows measured levels of turbidity. The Figure shows relatively high levels of turbidity in 1997-1998, and again in 2000-2001, likely related to storm runoff events. These more variable turbidity levels were followed by a trend of more steadily decreasing turbidity levels since 2001 through 2005. Turbidity levels in 1997-98 reached above 300 Nephelometric Turbidity Units (NTU’s), and reached near 250 NTU in isolated events in 2000-02. Turbidity levels in the most recent 2005 data range from 200 to below 50 NTU.

2.3.6.2. Dissolved Oxygen

Dissolved oxygen is measured by each program and is important to water quality. If dissolved oxygen becomes reduced in concentration to a point detrimental to aquatic organisms living in the system, a condition called hypoxia or oxygen depletion is the result. Dissolved oxygen is typically expressed as a percentage of the oxygen that would dissolve in the water at the prevailing temperature and salinity (both of which affect the solubility of oxygen in water). The concentration of dissolved oxygen in the water column at saturation, as measured in milligrams per liter (mg/l), varies with water temperature, salinity, and pressure. For example, the 100%

saturation dissolved oxygen concentration in water at 22 degrees Celsius with salinity of 30 parts per thousand is 7.33 mg/l. If the concentration measured 10 mg/l, the dissolved oxygen level would be at 136% (10 mg/l divided by 7.33 mg/l, then multiplied by 100).

SWMP Data



Volunteer Data

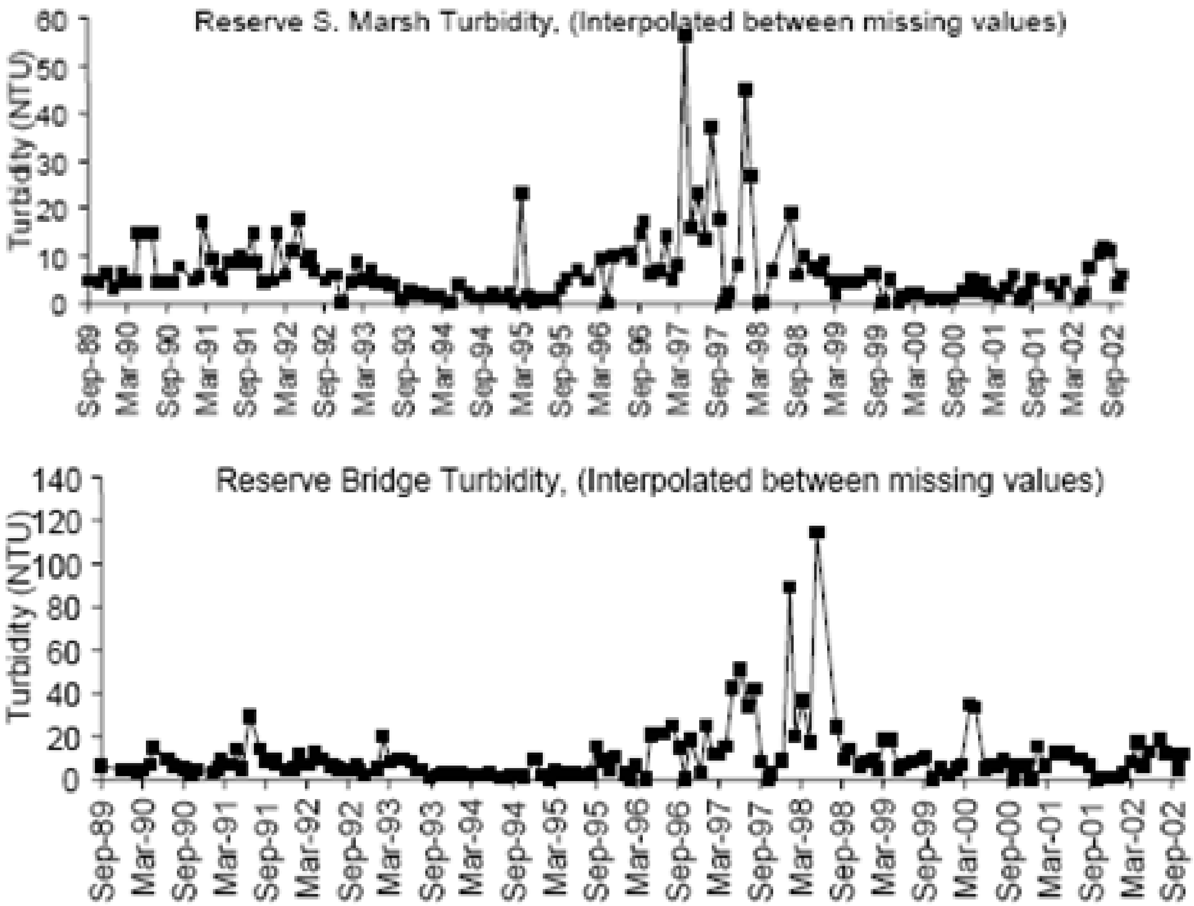


Figure 2-16 – Turbidity Level Readings by the SWMP and Volunteer Program

An aquatic system totally lacking dissolved oxygen (0% saturation) is termed anaerobic, reducing, or anoxic. A system with oxygen, but at a low dissolved oxygen concentration in the range between 1 and 30% saturation, is called hypoxic. Most fish cannot live below 30% dissolved oxygen saturation. A "healthy" aquatic environment should seldom experience dissolved oxygen less than 80%.

As estimated from the longer-term volunteer data, dissolved oxygen levels are 97% saturation in South Marsh and 92% saturation at the Reserve Bridge, both well-flushed sites similar hydrographically to the main channel (Caffrey et al. 2002). However, short-term anoxia can exist when dissolved oxygen levels can swing from between 0% saturation to over 200% saturation on the relatively infrequent extremes.

Data in Figure 2-17 measured by the SWMP (and to a limited extent by volunteers) show fairly large ranges in dissolved oxygen levels occurred on a frequency of approximately every other year (in 1995, 1996, 1999, 2001, and 2003). Extremes in dissolved oxygen levels tend to occur in Spring and Summer months, when “spikes” of high percent saturation around 200% saturation immediately precede drops to near 0% saturation during what are assumed to be episodic algal blooms. This appears to have occurred up to 6 times in that record. Some of these precipitous drops in dissolved oxygen tend to be short-lived, while others last a month or more.

Figure 2-17 also shows dissolved oxygen levels measured monthly by the volunteer program at South Marsh and at the Reserve bridge. These data are limited in their applicability owing to the method of one “grab” sample during the day. The data are recorded in milligrams per liter (mg/l) and range from approximately 1.5 mg/l to nearly 16.5 mg/l. Data for South Marsh fall within a similar range. The average of values 7.8 mg/l with a slight trend upward in values since 1995. Several readings drop below 5 mg/l which is also a cut-off point for potential low levels of concern for dissolved oxygen in a salt marsh (CRM 1996) indicating potential concerns.

While the SWMP and volunteer records provide less frequent but longer-term data, the LOBO data are shorter-term but more frequent (i.e., continuous data). Dissolved oxygen levels measured by LOBO in Parsons from August 2006 through June 2007 are shown in Figure 2-18 (Image A). The range of percent saturation was from a high of 197.5% to a low of 0.10% (both in 2007), with an average of approximately 80.8%. The site is well mixed with fairly high dissolved oxygen levels over time, but it also experiences spikes and drops in dissolved oxygen levels during the summer and fall seasons. The Parsons Complex is a site of very low dissolved oxygen levels during summer months that can persist for fairly long periods of time.

Short-term changes in dissolved oxygen at South Marsh and Azevedo Upper Pond over two 30 hour periods are shown in Figure 2-18 (Image B). The data represent one 30-hour period in summer 1997 and the same time period in winter 1997. South Marsh dissolved oxygen levels ranged from 60 to 120% saturation. In contrast, levels ranged from 0% to >250% saturation at Azevedo Upper Pond that is muted and received agricultural runoff.

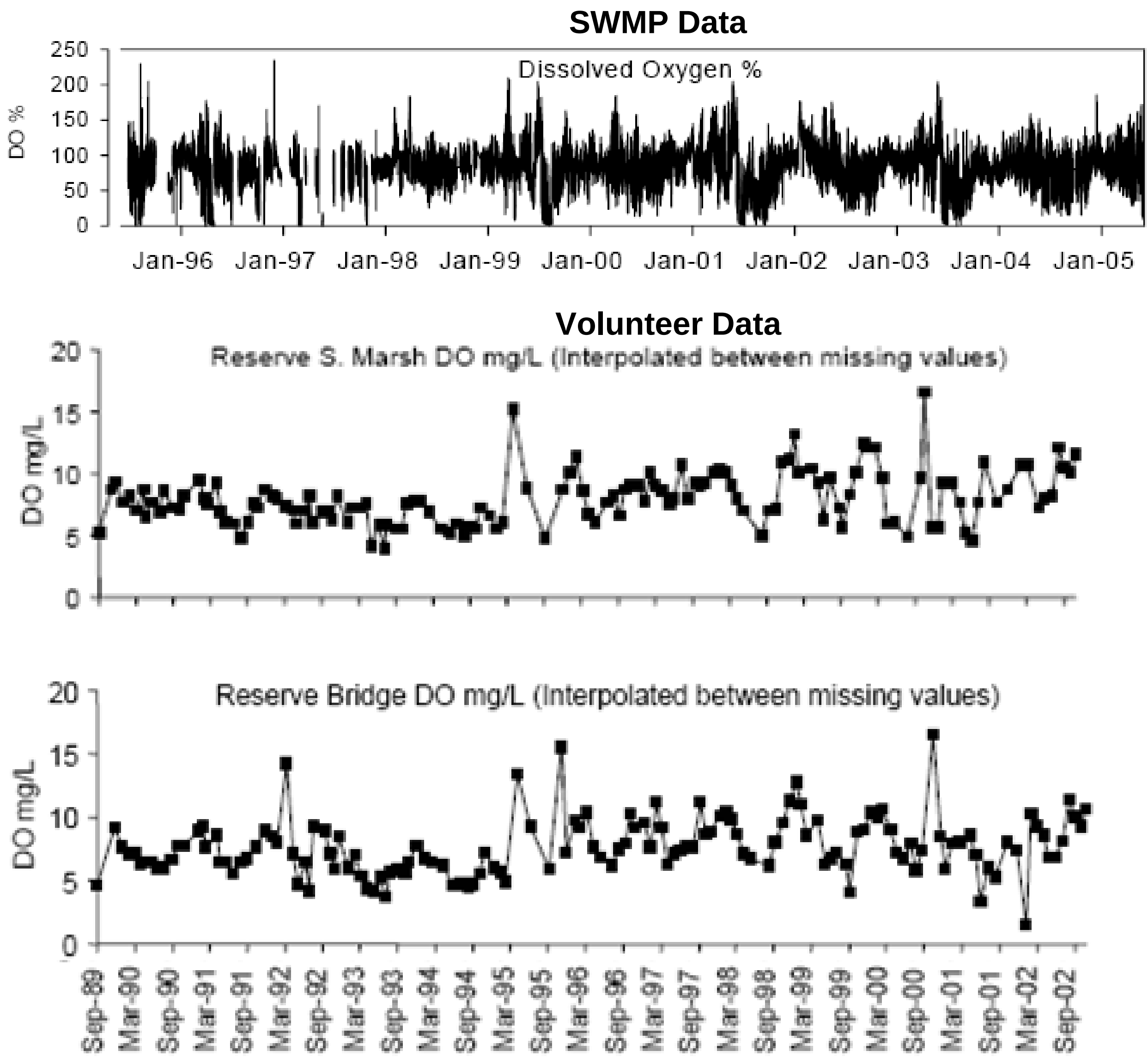


Figure 2-17 - Dissolved Oxygen Readings by the SWMP and Volunteers Program

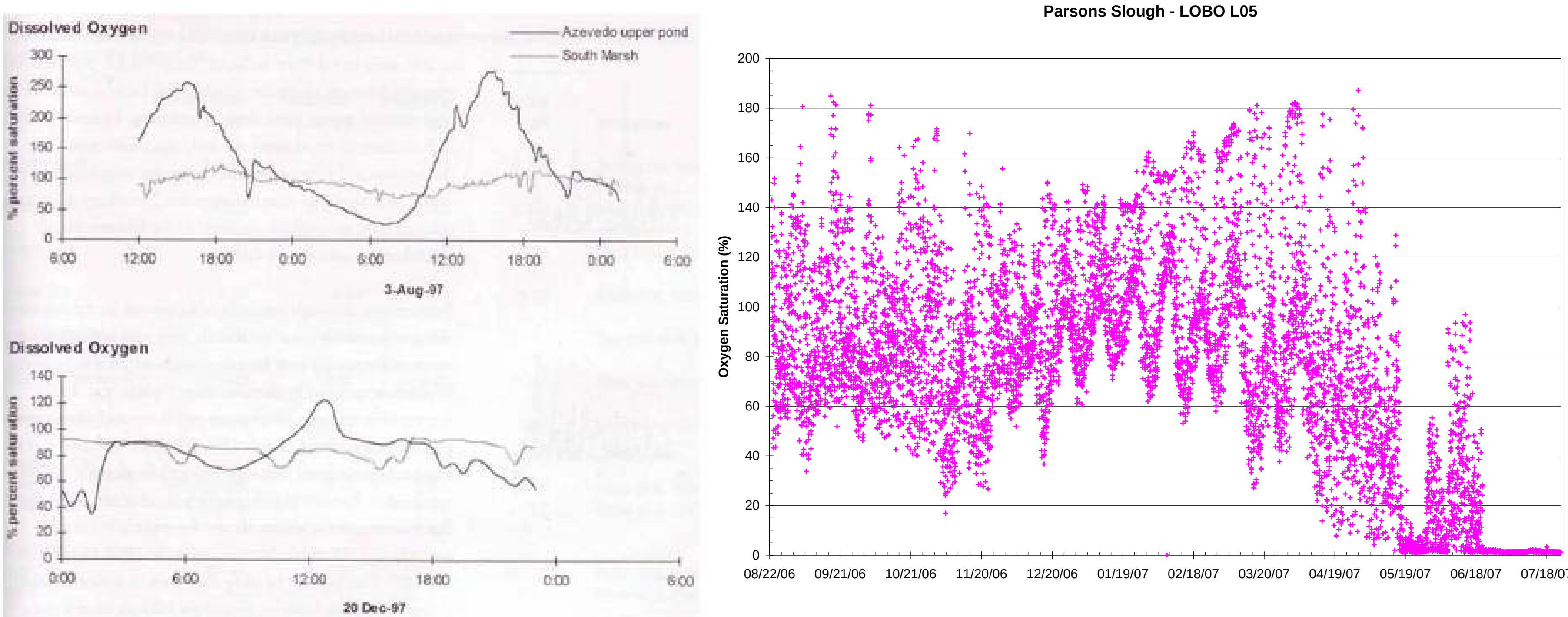


Figure 2-18 – A . (Left) Dissolved Oxygen Levels at Parsons from LOBO From Mid-2006 to Mid-2007; B. (Right) Comparison of Short-Term Dissolved Oxygen Levels at South Marsh and Azevedo Upper Pond from Caffrey et al. (2002)

Dissolved oxygen levels at South Marsh are fairly standard for a salt marsh, with some short-term drops under certain conditions (e.g., algal blooms). While this is cause for concern, it does not represent a significant constraint to a restoration scheme. Restoration that might call for restriction of tidal exchange should give close consideration to possible effects of low dissolved oxygen during these conditions.

2.3.6.3. Nutrients

Human activities have had a major impact on the function of the estuarine ecosystem of the Parsons Complex. Basic information of nutrient concentrations that relate to primary production and nutrient cycling is presented below. Since 1989, nutrient concentrations were measured monthly at the 24 stations used by the ESNERR and volunteers shown in Figure 2-12 as part of a systematic monitoring program (Caffrey et al. 2002). The two macronutrients that can limit primary production are nitrate and phosphorus.

Nitrate concentrations in Elkhorn Slough are generally very high at both the upstream and downstream ends when compared to other California estuaries, reflecting extremely high input concentrations from Carneros Creek and the Salinas River. They are also highest during the rainy season, indicating that runoff is a significant source of nitrate and perhaps other nutrients (Caffrey et al. 2002). However, concentrations measured at the UPRR bridge at the Parsons Complex and within South Marsh show relatively low concentrations compared to other areas of Elkhorn Slough as shown in Figure 2-19. The SWMP data show clearly that nitrate is contributed from the subwatershed during winter, and from the main channel (oceanic or from the Salinas River) in summer. As measured by LOBO and shown in Figure 2-20, nitrate levels at the Parsons Complex from August 2006 through April 2007 were typically below 20 micromoles per liter (mmol/l) with spikes above 40 mmol/l and up to 90 mmol/l in the spring season.

The role of phosphorus in controlling production in estuarine and marine environments is still debated (Caffrey et al. 2002). Usually, the ratio of dissolved inorganic nitrogen (DIN) to dissolved inorganic phosphorus (DIP) in the water column is compared with the 16N:1P ratio in phytoplankton. If the DIN:DIP ratio in a system is less than 16, nitrogen is probably limiting; if the ratio is greater than 16, phosphorus is limiting. The DIN:DIP ratios in Parsons Slough and South Marsh are less than 16 as shown in Figure 2-21, suggesting that phosphorus is not limiting (Caffrey et al. 2002).

Groundwater probably contributes little to nutrient levels in Elkhorn Slough, and thus to the Parsons Complex, because the flow of groundwater into the Slough has declined significantly as agriculture has increased (Caffrey et al. 2002). However, a recent Stanford thesis by Scott Wankel on groundwater in the Slough indicates that groundwater may be more of an important contributor of nutrients for the Slough than previously thought. Three main sources of nitrates include agricultural drainage, ocean upwelling, and nitrification of ammonia within the porewater of sediments at the Parsons Complex. This porewater component was the smallest contributor of the three sources (Wankel, et al. 2008).

Overall nutrient concentrations in the Parsons Complex and specifically within South Marsh are elevated above those of a completely natural wetland, but they are as not elevated as high as those at other areas of Elkhorn Slough. While nutrient concentrations at the Parsons Complex may be cause for concern in certain instances, they do not necessarily present a significant constraint to restoration. Due simply to the smaller watersheds contributing to the Parsons Complex, direct nutrient input to the site is lower in volume than that contributed directly into Elkhorn Slough from Carneros Creek upstream and the Salinas River downstream. The Parsons Complex does receive direct agricultural runoff into Rookery Lagoon and Parsons Slough from strawberry fields near the main entrance to the ESNERR (A. Woolfolk, Personal Communication 2007).

Tidal flushing is another factor that serves to disperse runoff with high nutrient concentrations throughout the Parsons Complex and out of the Complex into Elkhorn Slough. Tidal flushing appears to be sufficient to reduce build-up of nutrient concentrations in the water column and soils, and the site cycles nitrogen and phosphorus sufficiently to maintain a dynamic equilibrium of concentrations.

Caffrey's (2002) work was intended to identify problems with eutrophication, or excessive primary production, that causes problems with dissolved oxygen and other biogeochemical parameters within the Parsons Complex. Organic matter decomposition is indicated by sediment oxygen consumption rates. Sediment oxygen consumption rates at the Parsons Complex are relatively low compared to other areas of Elkhorn Slough that are more significantly impacted by agricultural runoff, meaning less organic matter is contributed from the watershed to the Parsons Complex (Caffrey et al. 2002). The conclusion from this work is that the Parsons Complex does not experience a condition of periodic eutrophication. Parsons Complex does periodically possess levels of nutrients above a natural salt marsh due to local watershed inputs and possibly nutrient inputs from Elkhorn Slough, but these levels do not presently represent a significantly degraded condition.

2.3.6.4. Salinity, Temperature, and pH

The other basic water quality parameters to consider are salinity, temperature, and pH. Salinity at the Parsons Complex according to NERR SWMP data is approximately that of seawater and is nearly identical to that in Elkhorn Slough. Figure 2-22 shows salinity patterns in the South Marsh SWMP water quality monitoring site from January 1996 to January 2005. Salinity levels visually appear to average 32 parts per thousand (ppt), with dips down toward between 10 and 20 ppt during certain events (assumed to be storm runoff events). The LOBO record from August 2006 through June 2007 shown in Figure 2-23 indicates that salinity is approximately that of

Figure 2-19 – Nitrate Concentrations (in Micromoles/Liter) Throughout Elkhorn Slough from Caffrey et al. (2002)

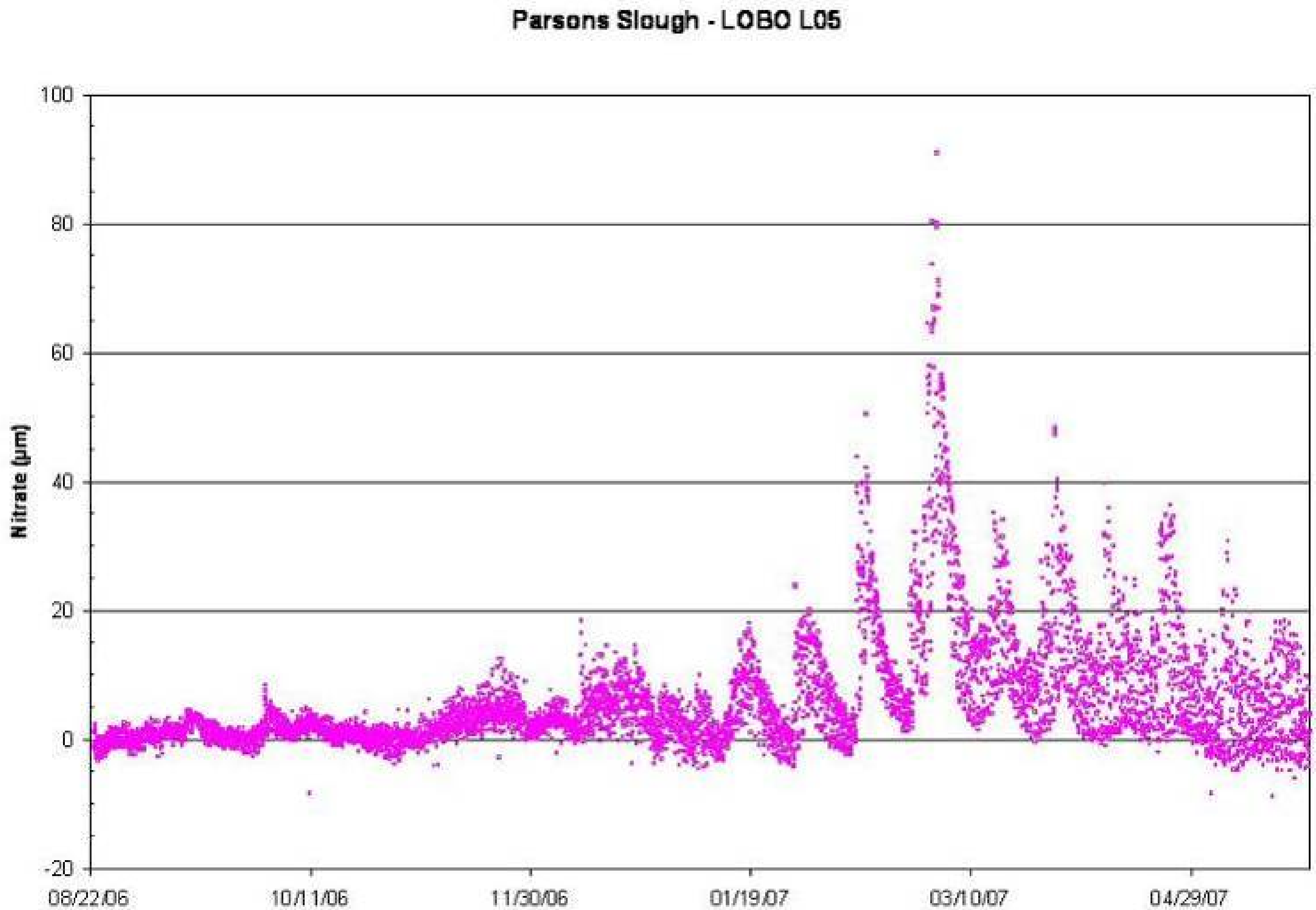


Figure 2-20 – Nitrate Levels in the Parsons Complex from LOBO

Sites Within the Parsons Complex → (Reserve Bridge, South Marsh)

	DIN:DIP RATIO	
	1970s	1990s
Skippers Restaurant	3.6	13.1
Old Salinas River channel	4.4	46.0
Kirby Park	5.0	8.5
Carneros	—	16.7
Hudson's Landing RC	—	8.1
Hudson's Landing LP	—	7.2
Lower Pond	—	0.7
Middle Pond	—	5.1
Upper Pond	—	17.2
Reserve Bridge	—	9.5
South Marsh	—	9.2
North Marsh	—	26.9
Moss Landing North	—	32.0
Moss Landing South	—	15.8
Moro Cojo Slough	—	6.5
Jetty Road	—	7.9
East Bennett	—	3.7
Struve Pond	—	1.2
Back Bennett	—	5.9
South Potrero	—	72.0
Tembladero Slough	—	81.0
Monterey Dunes Way	—	160.0
Salinas River Lagoon	—	207.0
Salinas River Bridge		366.0

Sources: Data for the 1970s are from Smith 1974 and Nybakken, Cailliet, and Broenkow 1977; 1990s data are from Caffrey et al. 1997.

Figure 2-21 – Nitrate to Phosphorus Ratios Throughout Elkhorn Slough from Caffrey et al. (2002)

seawater at 31.9 ppt throughout most of the year with the exception of drops down to a minimum of 18.2 ppt in the winter and spring months corresponding to rainfall events.

Similar salinity levels have also been recorded by the volunteer water quality monitoring program. Figure 2-22 also shows salinity recorded by volunteers from September 1989 to

September 2002 at the two locations at South Marsh near Whistlestop Lagoon and the Reserve Bridge. Levels at South Marsh average 31 ppt, but range more broadly with one instance of the site going fresh in 2001.

This reading is considered an anomaly associated with possible instrument error and is thus not yet assumed to be correct. Levels range from 0.1 to 59 ppt, but overall the site is typified by seawater salinity conditions. Salinity at the Reserve Bridge varies over time too, but averages 30.2 ppt with ranges of between 0.25 and 63 ppt. The site is essentially seawater with some limited time periods of freshwater influence.

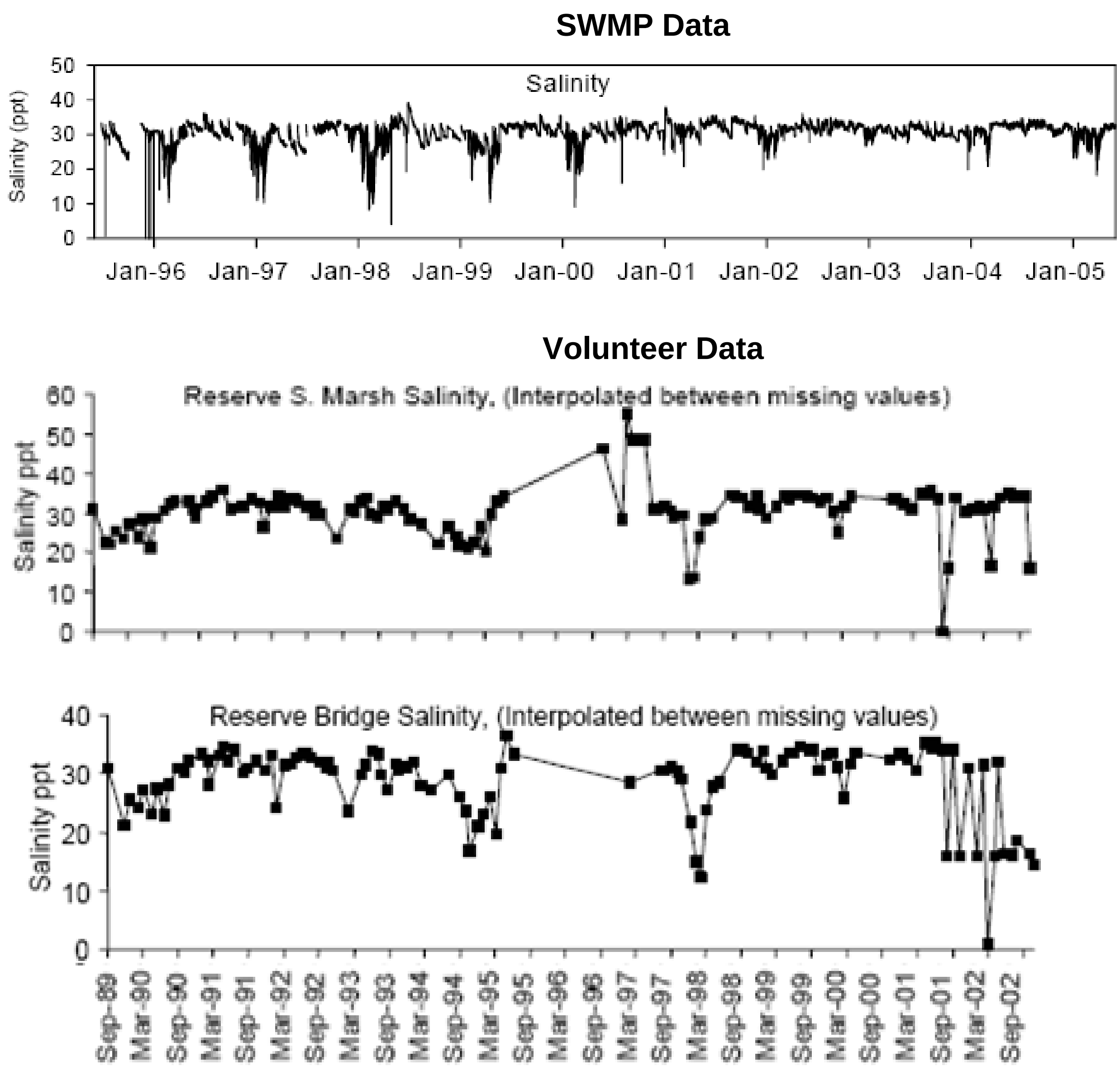


Figure 2-22 - Salinity Recorded by the SWMP and Volunteer Program

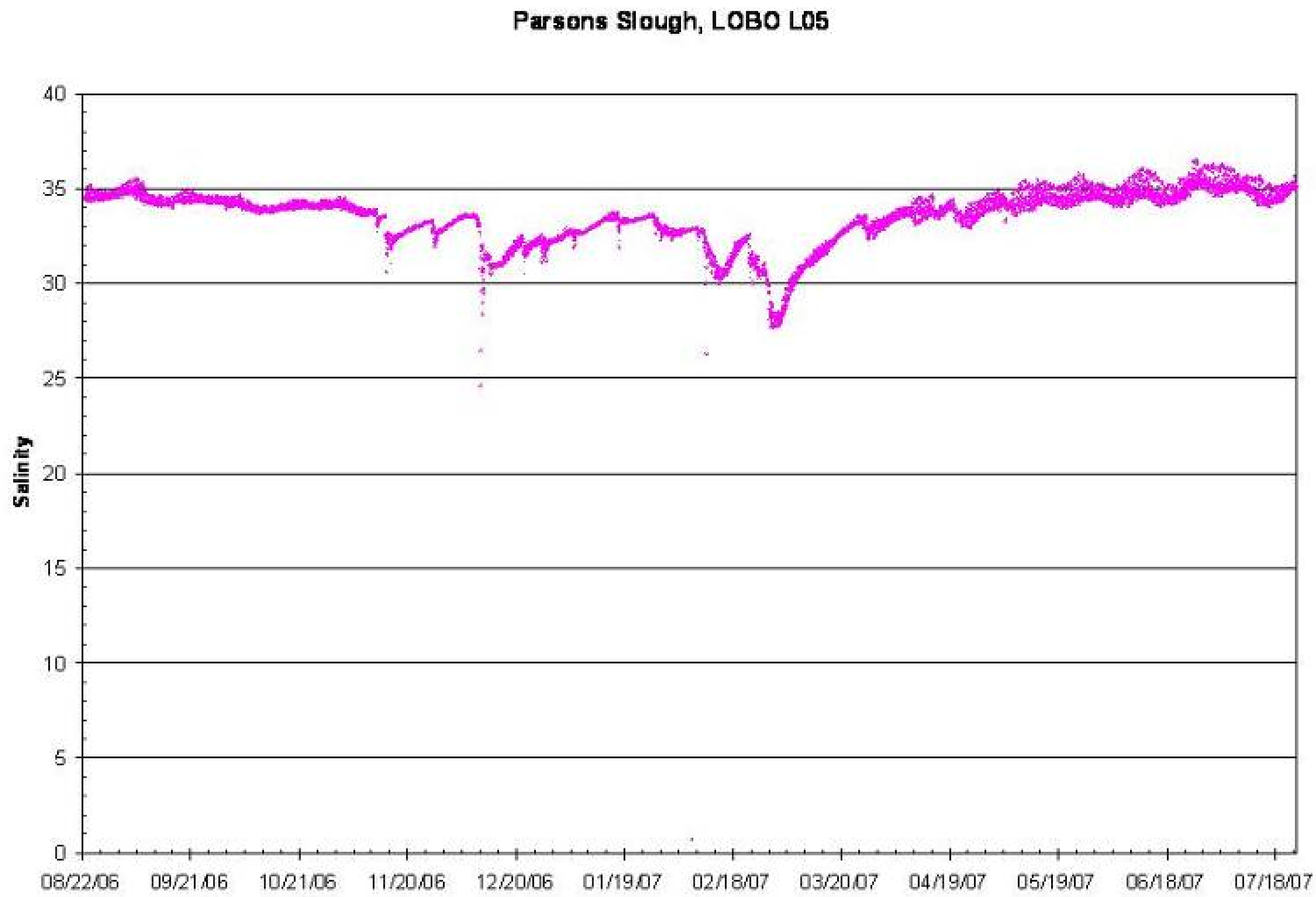


Figure 2-23 – Salinity Levels in the Parsons Complex from LOBO

Water temperature shown in Figure 2-24 recorded by the NERR SWMP from January 1996 to January 2005 ranges from a visually-estimated high of 25 degrees Celsius (C) (or 80 degrees Fahrenheit, or F) to 10 degrees C (or 50 degrees F). Variations are seasonal, with highest temperatures in the summer and lowest temperatures in the winter. The temperature pattern is steady and unchanging throughout the 10-year measurement period shown.

Water temperature data shown in Figure 2-24 obtained by the volunteers shows a nearly identical trend at both measurement sites and temperature values as those collected by SWMP. The range is from 7.8 to 25.0 degrees C and the fluctuations are seasonal, with highs in summer and lows in winter. Water temperatures are representative of a natural central California marine environment with no anomalies.

LOBO data in Figure 2-25 show a similar pattern over 2006-2007 but show one temperature drop in January 2007 down to 5.6 degrees Celsius (or 40 degrees F), and maximums of 24.6 degrees Celsius (86 degrees F) in summer.

Water pH levels shown in the ESNERR SWMP data in Figure 2-26 are fairly steady, with some variations, but the visually-estimated level averages 8.0 (slightly basic). Values of pH range from nearly 7.0 to 9.0. An anomaly appears to have occurred in 1997 with some large variation in 1996, but trends are more stable since those years up to 2005. Water conditions do not reflect large swings in pH levels and are representative of natural conditions.

Water pH levels collected by the volunteer program in South Marsh also shown in Figure 2-26 are fairly steady, with some variations, but average 8.1 (slightly basic). Values of pH range from 6.8 to 9.6. No significant anomalies appear, but greater variation seems to have occurred over the latter half of the data record than occurred in the first half of the record.

Levels of pH in water at the Reserve Bridge show a fairly steady trend with slightly greater variation. Values average 8.0 (slightly basic) and ranges extend from 6.0 to 9.7. An event of a significant dramatic pH swing seems to correlate with an event in spring 2001 when dissolved oxygen and pH peaked while temperature dropped. Overall the pattern is as would be expected from a natural environment, with greater variation caused by the influence of perimeter marsh areas.

2.3.7. Ecology

A full discussion of the ecology, habitat, and biology of the Parsons Complex is presented herein for wetland planning purposes.

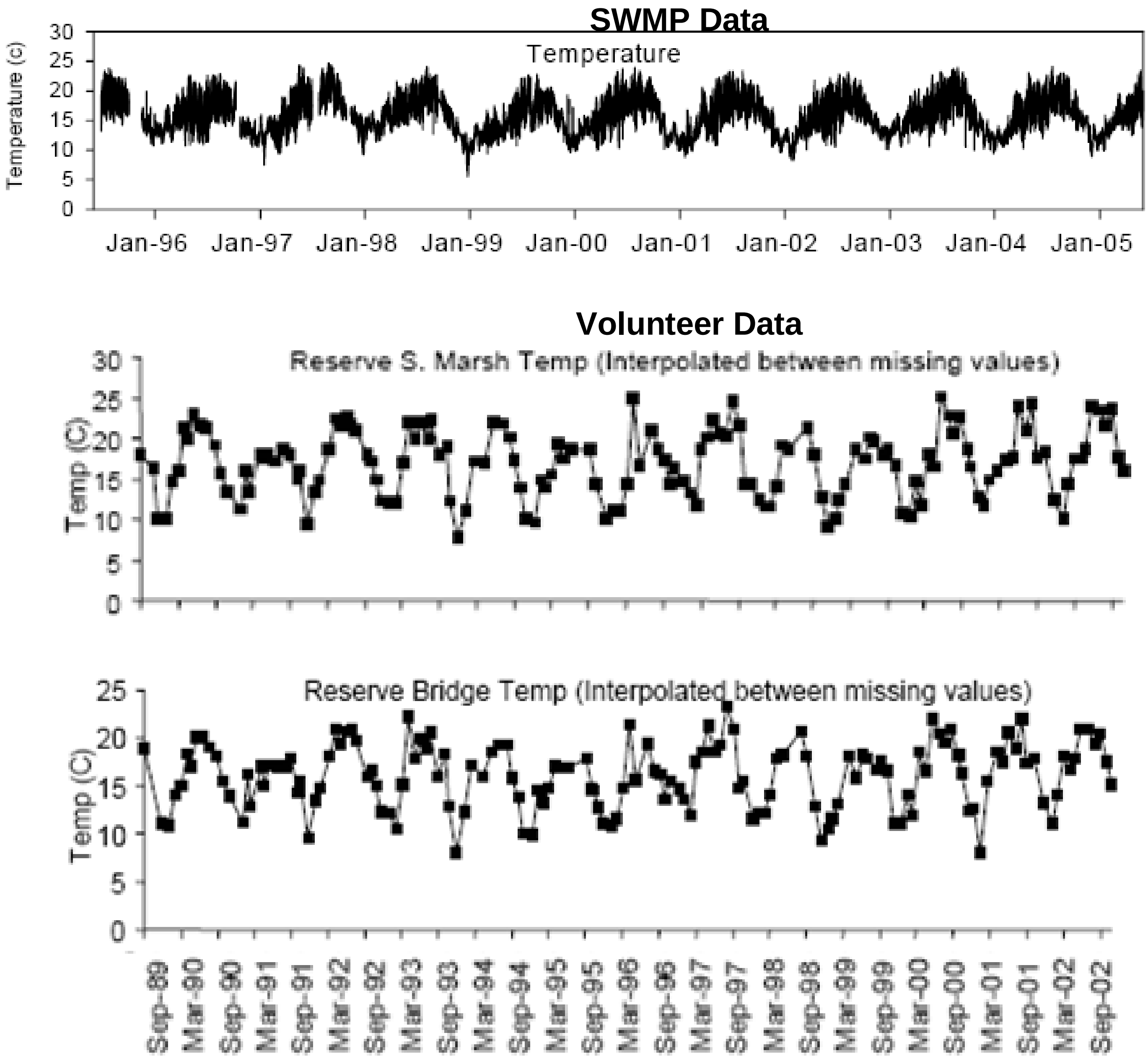


Figure 2-24 – Water Temperature Recorded by the SWMP and Volunteer Program

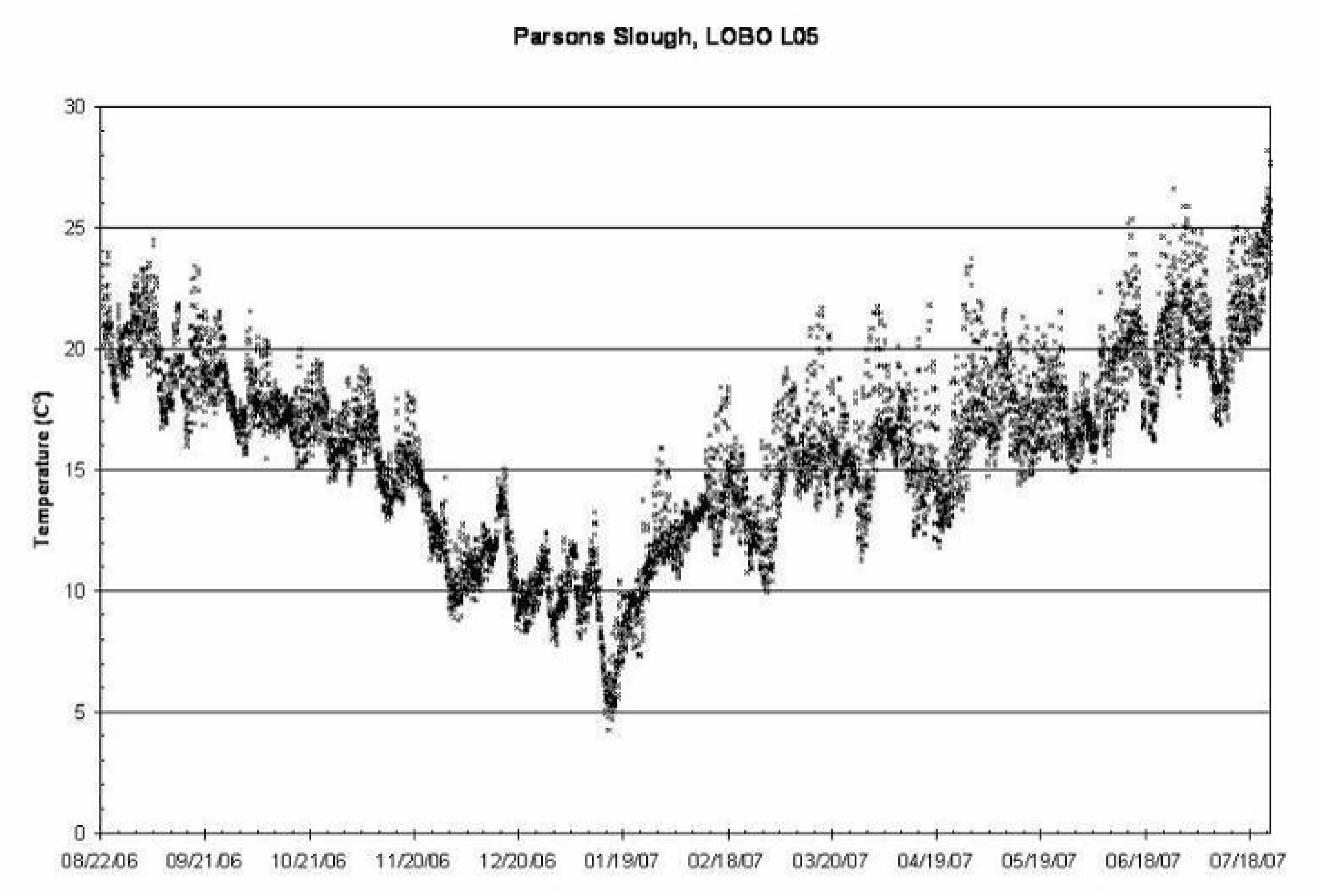


Figure 2-25 – Water Temperature in the Parsons Complex from LOBO

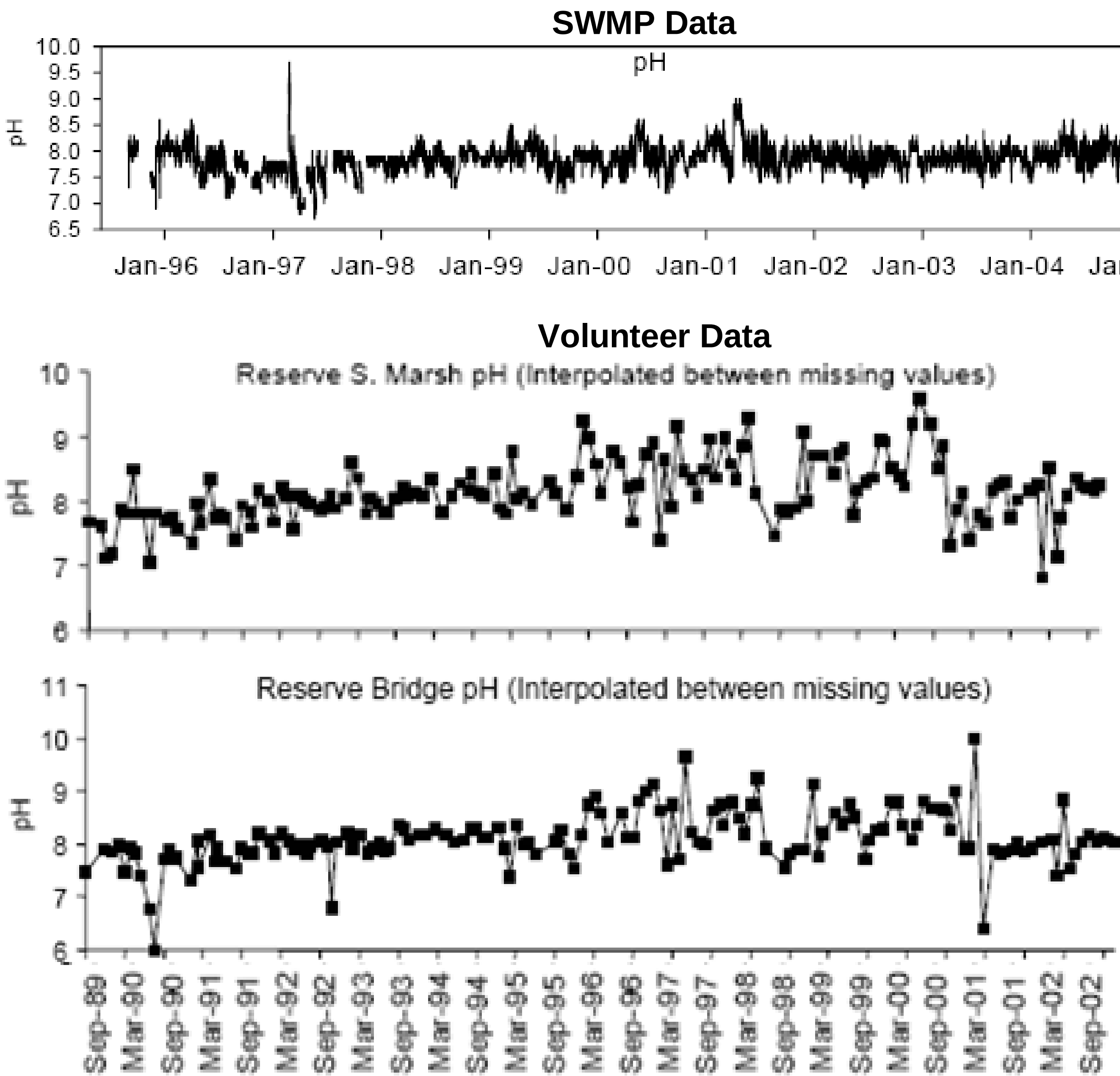


Figure 2-26 – Water pH Recorded by the SWMP and Volunteer Program

2.3.7.1. Habitats

2.3.7.1.1. Background

The Parsons Complex is dominated by mudflats intersected by subtidal channels. In the past, the Parsons Complex was dominated by tidal marsh and tidal creeks. As discussed earlier in this document, the diking and draining to convert wetlands to pastureland in the 1900s resulted in subsidence to an elevation that no longer can support marsh vegetation (ESTWPT 2007). The average land elevation in the Parsons Complex is now approximately 2.4 feet (0.7 meters) below the level that can support tidal marsh vegetation. Figure 2-27 shows typical tidal habitats relative to tidal level. Although cordgrass is shown on this figure because it is typical of low marsh in many areas, it does not occur naturally in Elkhorn Slough. Apart from constructed marsh islands in South Marsh and a narrow fringe of tidal marsh adjacent to upland areas, the present-day habitat type in the Parsons Complex is predominantly intertidal mudflats. Intertidal mudflats make up approximately 88% of the Complex.

2.3.7.1.2. Existing Habitat Distribution

Figure 2-28 shows the existing habitats in the Parson's Complex. Table 3 shows the acres of each habitat type as determined by the ESNERR (E. Van Dyke, Personal Communication 2007). Each habitat type is discussed below, with 10.3 acres of brackish and freshwater marsh areas included that are just outside of the formal project boundary, but important to the project.

Table 2-3 - Existing Habitats in the Parson's Complex

Habitat Type	**Acres**
Tidal Mudflat	377.6
Restricted Mudflat	10.4
Fully Tidal Salt Marsh	33.5
Restricted Salt marsh	3.2
Fresh or Brackish Marsh/Channel (Not Included)	0.6
Impounded Fresh Water (Not Included)	9.7
Subtidal Saltwater Channel	32.9
Intertidal Saltwater Channel	0.3
Total Acreage	**468.2**

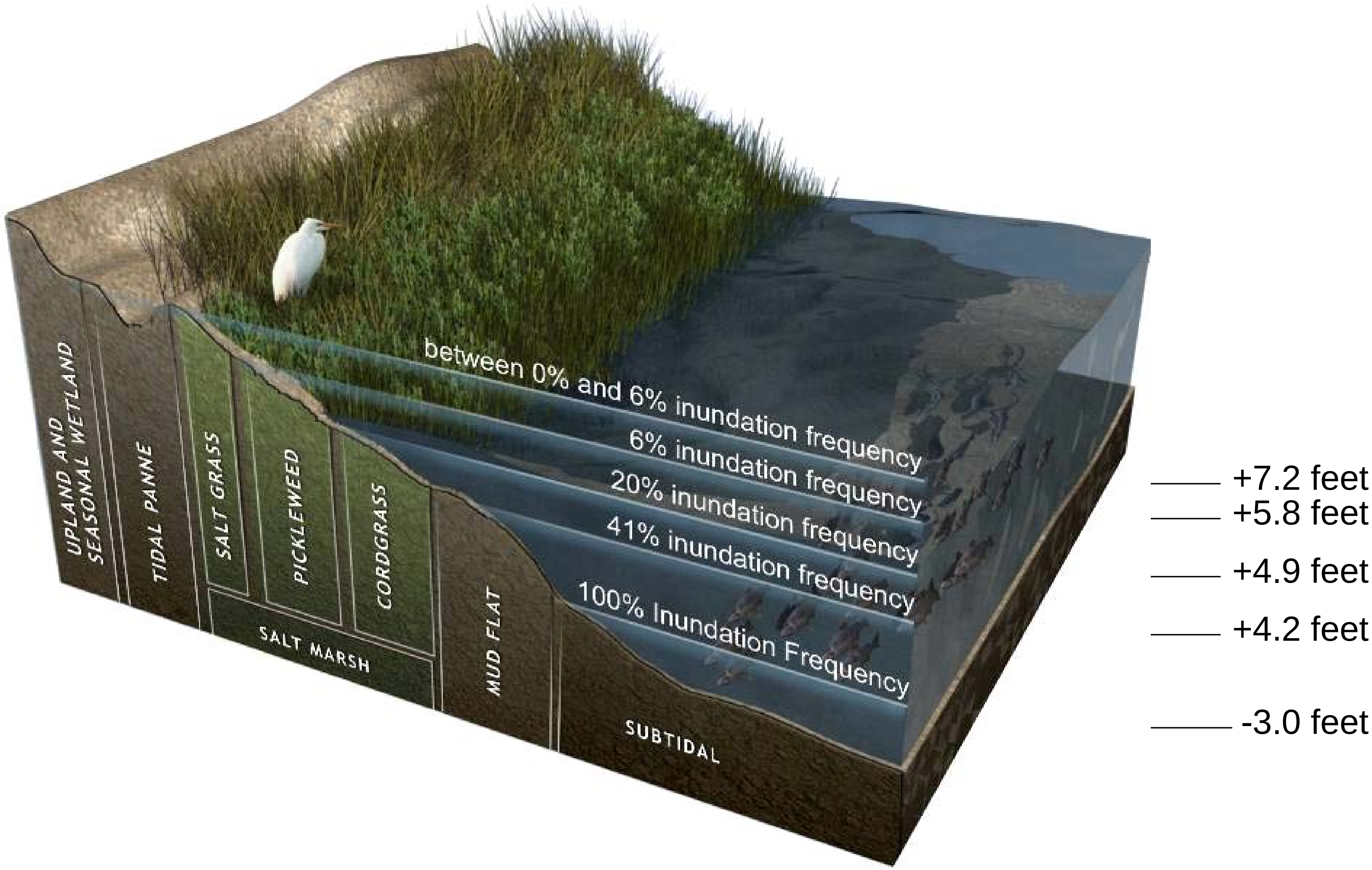
Tidal Mudflat (377.6 acres) - Mudflats are an intertidal habitat that is usually covered with water at high tide and exposed to the air at low tide. Intertidal mudflat is found at elevations between mean lower low water and the mean tide level. Mudflats are generally devoid of vegetation but may become covered with green algae (*Ulva* and *Enteromorpha*). Intertidal mudflats support a variety of invertebrates that supply a food base for shorebirds, marine mammals and fishes including sharks and rays.

Restricted Mudflat (10.4 acres) - Restricted mudflat is subjected to a muted tidal range. In the Parsons Complex, it occurs in Whistlestop Lagoon. The tidal range in Whistlestop Lagoon is significantly restricted by culverts.

Fully Tidal Salt Marsh (33.5 acres) - Salt marsh is habitat vegetated by persistent emergent plant species. Salt marsh habitat typically occurs at elevations of approximately + 4.7 feet (+1.4 meters) NAVD. In the Parsons Complex tidal salt marsh has been lost by erosion and subsidence and presently only occurs on created islands in South Marsh and along the fringes adjacent to uplands. Bank erosion has significantly decreased the length and width of the habitat islands in South Marsh since they were created. The fully tidal salt marsh habitat within the Parsons Complex occurs in very small patches depicted in Figure 2-28.

Salt marsh in the Parsons Complex is dominated by pickleweed (*Salicornia virginica)*. Vegetated tidal marsh contributes nutrients to the system and provides habitat for a variety of species including shore crabs (*Hemigrapsus oregonensis*) and song sparrows (*Melospiza melodia*) (E. Van Dyke and K. Wasson 2005). Many water birds such as great egrets use salt marshes as roosting sites during high tides. Although mid- to high salt marsh tends to be almost a monoculture of pickleweed, high salt marsh at the ecotone between wetland and upland tends to have a higher diversity of vegetation. Wasson and Woolfolk (2007) identified 5 native salt marsh plant species in the wetland/upland ecotone in five fingers in the Parsons Complex. These salt marsh species were pickleweed, salt marsh dodder (*Cuscuta salina*), salt grass (*Distichlis spicata*), alkali heath (*Frankenia salina*), and fleshy jaumea (*Jaumea carnosa*). The ecotone also supported four non-native upland plant species.

Restricted Salt Marsh (3.2 acres) - Restricted salt marsh is subjected to a muted tidal range. In the Parsons Complex muted tidal salt marsh occurs along the fringes of Whistlestop Lagoon. Wasson and Woolfolk (2007) identified only 2 native salt marsh plant species in the wetland/upland ecotone of Whistlestop Lagoon. These species were pickleweed and spearscale (*Atriplex triangularis*). The study also recorded one native upland species, coyote bush (*Baccharis pilularis*) and 5 upland non-native species. The ecotone study, which compared muted and full tidal sites at several locations in Elkhorn Slough, found that sites with tidal muting had a narrower ecotone width and lower total species richness, lower marsh species richness and lower species diversity compared to fully tidal sites (Wasson and Woolfolk 2007).



Note: Cordgrass does not occur in the Parsons Complex.

Figure 2-27 – Conceptual Section of Salt Marsh Habitats

Brackish/Fresh Marsh (0.6 acres) - This marsh habitat occurs at the upper end of the second finger and is not included within the project area. Brackish marsh habitat has water that is saline but well below the salinity of seawater (approximately 0.5 to 18 ppt). This habitat supports plant and animal species that are adapted for a range of saltwater to freshwater conditions. Characteristic vegetation includes bulrush, cattail and pickleweed.

Impounded Freshwater Ponds (9.7 acres) - This habitat consists of non-tidal freshwater marsh behind a levee. This habitat is represented by several ponds, including the Rookery Ponds, Cattail Swale, five fingers, and the Barn Ponds, in the Parsons Complex. These ponds were created by diking off small portions of marsh in the early half of the last century. The ponds are fed by rainwater and groundwater and receive no tidal influence (Hemmingway et al 2005). These ponds support sensitive reptiles and amphibians including western pond turtles (*Clemmys marmorata*), California red-legged frogs (*Rana aurora draytonii*), and Santa Cruz long-toed salamanders (*Ambystoma macrodactylum croceum)*. The freshwater pond areas are not included in the Parsons Slough Wetland Restoration Plan, which focuses on tidal areas.

Saltwater Channel (subtidal 32.9 acres, intertidal 0.3 acres) - Saltwater channels generally occur below the elevation of Mean Lower Low Water and, thus, are permanently covered with water. Approximately 0.3 acres on the edges of the channels are exposed at low tides. The saltwater channels in the Parsons Complex are subjected to the full tidal range. They form a network amongst mudflats and salt marsh and connect to the main channel of Elkhorn Slough. These channels serve as nurseries and foraging areas for many species of fish as well as piscivorous birds, harbor seals and sea otters. They convey sediments and nutrients between mudflats and salt marsh habitats and the main channel.

2.3.7.2. Key Indicator Species

Key indicator species including benthic invertebrates, fishes, birds, marine mammals and eelgrass are presented below.

2.3.7.2.1. Benthic Invertebrates

A rapid assessment of relative abundance of large mudflat invertebrates was conducted at 12 mudflat sites within Elkhorn Slough (K. Wasson, Personal Communication 2007). Four of these sites were within the Parsons Complex as follows: 1) within the main Parsons Slough area; 2) Long Valley; 3) South Marsh; and 4) within the muted tidal area in Whistlestop Lagoon. These surveys of large mudflat invertebrates showed that the communities in the full tidal portions of the Parsons Complex are broadly similar to those in the Elkhorn Slough main channel intertidal. The exception is the restricted mudflat habitat in Whistlestop Lagoon, which has a somewhat different mudflat invertebrate assemblage. Three species of clam (*Saxidomus nutalli, Venerupis japonica* and *Irus lamellifer)* were found at Whistlestop Lagoon but not at the other Parsons Complex sites. Of key benthic indicator species, the fat innkeeper worm (*Urechis caupo*) was found at the South Marsh and Parsons Slough sites but not in Long Valley or Whistlestop

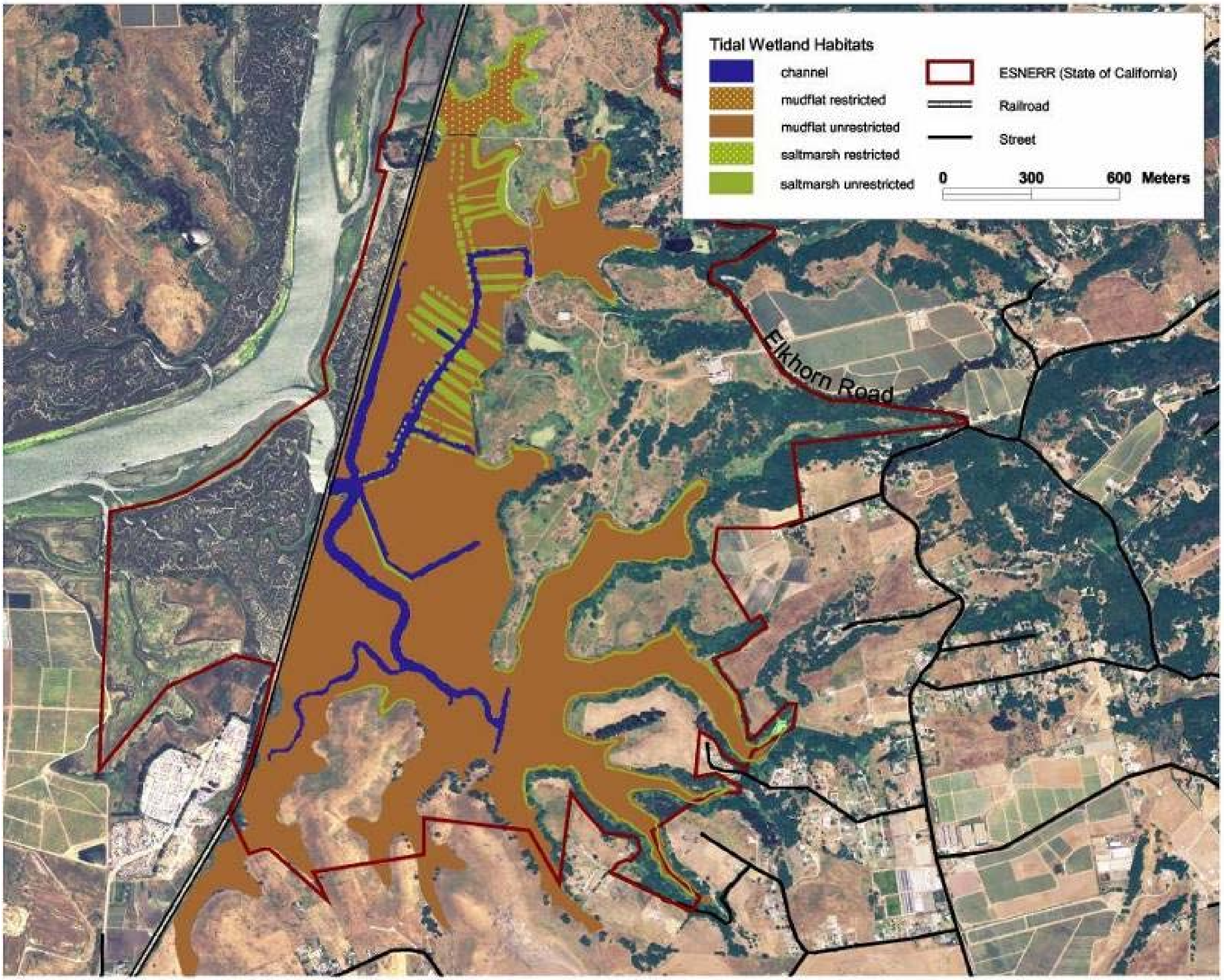


Figure 2-28 – Existing Habitats Within the Parsons Complex

Lagoon. Fat innkeeper worms were not found at any sites with a muted tidal regime in the study. Razor clams (*Tagelus californianus*) were found in all four Parsons Complex sites but were most abundant in Whistlestop Lagoon and least abundant in South Marsh. Ghost shrimp (*Neotrypaea californica*) were found in Long Valley and Parsons Slough but not in Whistlestop Lagoon or South Marsh.

Oyster surveys conducted by Wasson and Schmidt (2007) at six sites in the Elkhorn Slough found that the Parsons Complex also contains live oyster (*Ostreola conchaphila*) populations. Two of the surveyed sites were within the Parsons Complex: South Marsh and Whistlestop Lagoon. Based on transects, the investigators estimated the total number of live oysters per site. They estimated that there were approximately 500 at South Marsh and 500 at Whistlestop Lagoon. They estimated that based on hard substrate Elkhorn Slough as a whole has about 6,000 live oysters with at most 10,000. Therefore the oyster population in the Parsons Complex probably represents 10 to 20 percent of the entire Elkhorn Slough live oyster population. The mean size of the oysters was 44.8 millimeters (mm) at South Marsh and 47.2 mm at Whistlestop Lagoon. Threats to Parsons Complex oysters include leafy algae (*Ulva*) covering oysters at Whistlestop Lagoon and burial of oysters on small rocks by mud at South Marsh.

In April and August 2005, fishes and crabs were sampled in the full tidal regime of South Marsh and the muted tidal habitat of Whistlestop Lagoon using seines, small minnow traps and larger rectangular fish traps (Ritter et al. 2007). European green crabs (*Carcinus maenus*) and yellow shore crabs (*Hemigrapsus oregonensis*) were collected in both areas. Pacific rock crabs (*Cancer antennarius*) were collected in Whistlestop Lagoon but not in South Marsh.

2.3.7.2.2. Fishes Including Sharks and Rays

Information on the fishes of Elkhorn Slough, including the Parsons Complex was summarized by Yoklavich et al. (2002). The fish fauna of Elkhorn Slough is abundant, diverse and dominated by marine and estuarine species. From the 1970s to the 1990s, several detailed surveys were done of the main Elkhorn Slough Channel and tidal creeks including Long Valley within the Parsons Complex. During this time fish assemblages have changed. In the 1970s fish assemblages near the mouth of Elkhorn Slough were very different from those of tidal creeks. By the 1990s those geographical differences had disappeared and assemblages in the tidal creeks resembled those of the lower Elkhorn Slough. These changes in fish assemblages coincide with the continued erosion and scouring of Elkhorn Slough, which has resulted in a geomorphology of the tidal creeks that is now more similar to that of the main Elkhorn Slough channel.

Table 4 compares the fish assemblage in Long Valley in Parsons Complex between 1974 and 1980 and between 1995 and 1996. Between 1974 and 1980 Long Valley supported seven dominant fish species and the assemblage was estuarine in character. In 1995 and 1996, the Long Valley samples were dominated by only three species including two species, northern anchovy (*Engraulis mordax*) and Pacific herring (*Clupea pallisi)*, that are marine immigrants Thus the fish assemblage in Long Valley had changed from one dominated by estuarine species to one dominated by marine species.

Table 2-4 - Comparison of Percentage Abundance of Fish Species in Long Valley Between 1974-1980 and 1995-1996

	Lifestyle *	1974-1980	1995-1996
Starry flounder (*Platichthys stellatus)*	MI	5.9%	--
Black surfperch (*Embiotica jacksoni*)	R	3.7%	--
Pacific staghorn sculpin (*Leptocottus armatus*)	R	51.2%	--
Queenfish (*Seriphus politus*)	MI	9.5%	--
Topsmelt (*Atherinops affinis*)	PR	4.9%	--
Arrow goby (*Clevelandia ios*)	R	3.7%	--
Leopard shark (*Triakis semifasciata*)	PR	3.7%	--
Shiner Surfperch (*Cymatogaster aggregate*)	PR	--	48.1%
Northern anchovy (*Engraulis mordax)*	MI	--	17.3%
Pacific herring (*Clupea pallisi)*	MI	--	16.2%

*Lifestyle - MI = Marine immigrant, R = Resident, PR =Partial resident

Source:Yoklavich et al 2002

Yoklavich et al. (2002) summarized surveys by Small in South Marsh before and after its restoration to tidal flow. Fish species collected in South Marsh before and after the restoration are shown in Table 5. Pre-restoration surveys in April and August 1983 collected a fairly high abundance of nine small species. The most abundant species was the euryhaline three-spined stickleback (*Gasterosteus aculeatus*). Samples taken in 1984 after South Marsh was opened to tidal influence had higher diversity (16 species) but lower abundance. The dominant species were Pacific staghorn sculpin (*Leptocottus armatus*) and northern anchovy (*Engraulis mordax).* In subsequent monthly surveys of South Marsh through 1985, 10 species were consistently abundant.

More recent sampling of fishes and crabs was done in the Parsons Complex in April and August 2005 (Ritter et al. 2007). Fishes and crabs were sampled in the full tidal regime of South Marsh and the muted tidal habitat of Whistlestop Lagoon using seines, small minnow traps and larger rectangular fish traps. Table 6 lists fish species collected in South Marsh compared to species collected in Whistlestop Lagoon. The surveys suggested that the fish assemblage in the full tidal South Marsh area was fairly similar to that in the muted tidal habitat of Whistlestop Lagoon. Six of the 11 species collected in the survey were found in both areas.

The Parsons Complex is heavily used by various species of sharks and rays for foraging and pupping. Seven species of sharks and rays commonly inhabit Elkhorn Slough including the Parsons Complex. These are leopard sharks, bat rays (*Myliobatis californica*), shovelnose guitarfish (*Rhinobatos productus*), thornbacks (*Platyrhinodis triseriata*), gray smoothhounds (*Mustelus californicus*), brown smoothhounds (*Mustelus henlei*) and round stingrays (*Urolobatis halleri*) (Carlisle 2006, PSRF 2004).

The Pelagic Shark Research Foundation (PSRF) catches sharks and rays within the Parsons Complex using entanglement nets and beach seine nets (http://www.pelagic.org/slough). Between 2001 and 2004 the most abundant species found by PSRF in the Parsons Complex was thornback rays followed by bat rays. Shovelnose guitarfish and leopard sharks were collected in lower numbers, and smoothhounds and round stingrays made up a small percentage of the catch. They found evidence that thornbacks were using the tidal channels and lagoons of the Parsons Complex for incubation and predator evasion during late term pregnancy, and giving birth.

Leopard sharks are seasonally abundant in Elkhorn Slough during the spring through fall, and generally leave in the winter when temperature and salinity levels decrease (Carlisle 2006). In a study of movements and habitat use of tagged female leopard sharks in Elkhorn Slough, Carlisle (2006) found that they used the Parsons Complex extensively throughout the year, but especially during spring and summer. The Parsons Complex appeared to be important as both a foraging and nursery area, probably due to the large amount of intertidal mudflats, which support abundant prey items for the sharks.

The low intertidal mudflats that leopard sharks used at intermediate and high tidal levels were primarily found along the northern and eastern boundary of the Parsons Complex. Tagged sharks particularly used Rookery Lagoon, the northern part of South Marsh, and the five fingers region, the second finger in particular. They were frequently observed making direct rapid directed movements of hundreds of meters across mudflats to these areas of low intertidal mudflats, where they would remain until tidal levels dropped, at which time they would make rapid directed movements back to the channel. These movements were regular and highly predictable. The sharks were generally in the upper parts of the Complex and would usually only move down to the entrance around lower low tides.

Table 2-5 – Abundance of Fish Species Collected in South Marsh Before and After Restoration to Tidal Flow[1]

Fish Species	Lifestyle[2]	1984 Before	1985 After	Fall 1984 - 1985
Three-spined stickleback	F	D		
Pacfic staghorn sculpin	R	C	D	C
Pacific herring	MI	C		
California tonguefish	MI	C	C	C
Arrow goby	R	C	C	C
Northern anchovy	MI	C	D	C
Shiner surfperch	PR	C	C	C
Jacksmelt	PR	C	C	C
Pacific herring	MI		C	
Longjaw mudsucker	R		C	
Plainfin midshipman	MI		C	
English sole	MI		C	C
Yellowfin goby	R		C	
California halibut	MI		P	C
Bay goby	R		C	
Bay pipefish	R		P	
Pacific sardine	M		P	
Starry flounder	MI		P	C
Diamond turbot	MI		P	
Bat ray	PR		P	C

[1] Relative abundance D = dominant, C = common, P = Present
[2] Lifestyle -F = Freshwater, MI = Marine immigrant, R = Resident, PR = Partial resident
Source:Yoklavich et al 2002

Table 2-6 - Fish Species Collected in South Marsh and Whistlestop Lagoon in April and August of 2005

Fish Species	Lifestyle*	South Marsh (Full Tidal)	Whistlestop Lagoon (Muted Tidal)
Topsmelt (*Atherinops affinis*)	PR	X	X
Arrow Goby/Bay Goby	R	X	X
Shiner Surfperch (*Cymatogaster aggregate*)	PR	X	
Longjaw mudsucker (*Gillichthys mirabilis*)	R	X	X
Pacific staghorn sculpin (*Leptocottus armatus*)	R	X	X
California halibut (*Paralichthys californicus*)	MI	X	X
Thornback (*Platyrhinodis triseriata*)	M	X	
Plainfin midshipman (*Porichthys notatus*)	MI	X	X
Northern anchovy (*Engraulis mordax)*	MI		X
Bay pipefish (*Syngnathus leptorhynchus*)	R		X
Fantail sole (*Xystreurys liolepis*)	M		X

*Lifestyle - MI = Marine immigrant, R = Resident, PR =Partial resident

Sharks were observed to swim against strong ebb currents to remain in the Parsons Complex. Carlisle suggested that the tidal pattern of habitat use in the Parsons Complex likely is due to leopard sharks foraging intertidally, especially on fat innkeeper worms. Carlisle also noted extensive use of the Parsons Complex by pregnant leopard sharks during the pupping period, which suggested that the Complex is a primary nursery area. Rookery Lagoon, which has a large amount of intertidal mudflats, in particular appeared to be a specific area that was used as a nursery area. Leopard shark use of the Parsons Complex diminishes in the late summer or fall when dissolved oxygen decreases and temperatures increase. At this time of year leopard sharks spend more time in the Elkhorn Slough main channel, which is more environmentally stable.

Carlisle (2006) notes that in the 1970s the tidal creeks that branch off the main channel were used as nursery areas by leopard sharks. However, because of erosion the tidal creeks have gotten wider and deeper, which seems to have affected their nursery function. Carlisle found no evidence of leopard sharks using those tidal creeks in his study so the importance of these habitats as nursery and foraging areas appears to have diminished. The role that was previously filled by tidal creeks now appears to be filled by the Parsons Complex, which presently appears to be the primary leopard shark nursery habitat in Elkhorn Slough.

2.3.7.2.3. Birds

From December 2001 to September 2003, docents, volunteers and ESNERR staff conducted biweekly bird observations in part of the restored South Marsh (Fork 2004). The area surveyed consisted of a group of emergent, mostly vegetated (pickleweed) islands just east of the UPRR bridge as well as the surrounding mudflats. Birds were listed in broad, easily recognizable categories including cormorants, gulls, brown pelicans, white pelicans, Caspian terns, great egrets, snowy egrets, and great blue herons. In determining species richness each bird category was considered as a single species. The survey found that many species of birds used the restored South Marsh including diving birds such as cormorants and pelicans, waders (herons and egrets), and many shorebirds. Cormorants were the most abundant bird, averaging 44 individuals per count followed by gulls averaging 33 birds per count and Caspian terns (*Hydroprogne caspia)* averaging 20 birds per count. Brown pelicans (*Pelecanus occidentalis californica*) and white pelicans (*Pelecanus erythrorhynchus*) each averaged about 10 birds per survey. Overall per survey, an average of 94 birds was counted on islands and 27 on mudflats. Islands averaged twice the number of species per count as mudflats. Abundance was greater on islands on high tides compared to low tides. Use of mudflats was slightly greater on low tides compared to high tides. At higher tides many birds appear to use the islands when the mudflats are submerged. Results from this survey suggest that reducing tidal erosion may be necessary to preserve the remaining emergent island habitat for these birds in the Complex. Alternatively, islands used by birds could also be allowed to erode and new islands may be better constructed elsewhere as part of the project.

Waterbird observations also have been reported for 26 sites in greater Elkhorn Slough between 1992 and 1999 (Fork 2002). These sites included two within the Parsons Complex: South Marsh and the Reserve Bridge. These sites were intermediate in terms of total annual abundance of birds compared to all the sites. South Marsh had a mean annual bird abundance of about 100 birds per year. The Reserve Bridge site averaged about 200 birds per year. In comparison the Salinas River Lagoon averaged nearly 9,000 birds annually. The Reserve Bridge site supported relatively high bird diversity and South Marsh had an intermediate average annual bird diversity. The South Marsh site supported a relatively low mean abundance of shorebirds (about 10 per year) while the Reserve Bridge site had a relatively high annual shorebird abundance (about 100 per year). Mean waterfowl abundance was relatively low at both Parsons Complex sites (less than 10 for Reserve Bridge and about 20 for South Marsh). Between 15 and 20 egrets were counted each year at the Reserve Bridge site. The South Marsh site was notable for consistently supporting belted kingfishers.

From March 1999 to July 2000 shorebird surveys were conducted at low tide at five fingers and South Marsh (full citation in the Ritter et al. Masters Thesis as well as in the ESNERR bibliography). Shorebird species observed at five fingers included American avocet (*Recurvirostra mericana*), black-bellied plover (*Pluvialis squatarola*), black-necked stilt (*Himantopus mexicanus*), long-billed curlew (*Numenius americanus*), short /long-billed dowitchers (*Limnodromus griseus/scolopaceus*), dunlin (*Calidris alpine*), least sand piper (*Calidris minutilla*), marbled godwit (*Limnosa fedoa*), sanderling (*Calidris alba*), western sandpiper (*Calidris mauri*), and willet (*Catoptrophus semipalmatus*). The same shorebird species were observed at South Marsh except that black-necked stilts and sanderlings were not observed at South Marsh.

A rookery of great egrets (*Ardea alba*), double-crested cormorants (*Phalacrocorax auritus*) and great blue herons (*Ardea herodias*) is located on the edge of Rookery Pond, a diked pond, former estuarine habitat that is part of the Parsons Complex. The rookery began in about 1985, shortly after the Parsons Complex and the North Marsh Complex were returned to tidal exchange. The tidal areas within the Parsons Complex provide important foraging habitat for the birds breeding within this rookery. In 2007, the rookery was nearly empty of birds when the annual mid-June survey was done (K. Wasson, Personal Communication 2007). The reason for the low nesting success is unknown.

A breeding colony of Caspian terns began nesting on a constructed island in the restored South Marsh in 1992 (URL: http://www.elkhornslough.org 2004). The colony suffered reproductive failure in 1995, probably because of DDT introduced to the system from flooding of the Pajaro River (Parkin 1998), and in 2000 and 2004 because of predation (Wasson, Personal Communication 2007).

2.3.7.2.4. Marine Mammals

Sea otters (*Enhydra lutris*) regularly use portions of the Parsons Complex, especially Whistlestop Lagoon and nearby areas (Wasson, Personal Communication 2007). Harbor seals (*Phoca vitulina*) haul out and pup in large numbers just outside of the Complex (west of the Parsons Slough railroad bridge), and in recent years dozens of them often haul out in shallow mudflats (particularly on degraded old dikes and berms) within Parsons Slough in the area east of the railroad bridge. Harbor seals use the Parsons Complex during pupping season, which extends from mid-March to mid-June (Kinghorn and Goggin 2002).

2.3.7.2.5. Eelgrass

Eelgrass is a marine flowering plant that functions as important habitat for a variety of fish and wildlife species. Eelgrass grows in soft sediments in estuaries and coastal bays. Eelgrass canopy (consisting of shoots and leaves approximately two to three feet long) attracts many marine invertebrates and fishes and the added vegetation and the vertical relief it provides enhances the abundance and the diversity of the marine life compared to areas where the sediments are barren. The vegetation also serves a nursery function for many juvenile fishes. A diverse community of bottom-dwelling invertebrates lives within the soft sediments that cover the root and rhizome mass system.

Eelgrass meadows are critical foraging centers for seabirds (such as the endangered California least tern) that seek out baitfish such as juvenile topsmelt attracted to the eelgrass cover. In addition, eelgrass is an important contributor to the detrital food web of bays as the decaying plant material is consumed by many benthic invertebrates (such as polychaete worms) and reduced to primary nutrients by bacteria.

Eelgrass was once common in Elkhorn Slough but declined greatly since the 1920's (Zimmerman and Caffrey 2002). In recent years it has expanded somewhat and helped to offset some of the Slough's loss of ecological function associated with erosion of pickleweed marsh (Zimmerman and Caffrey 2002). Eelgrass occurs in the entrance channel to the Parsons Complex west of the UPRRR Bridge but not within the Complex itself. Exploratory eelgrass studies were conducted in South Marsh, Whistlestop Lagoon and Rookery Lagoon in 1988 and 1989 but ultimately failed.

2.3.7.2.6. Sensitive Species

The table in Appendix 2-A lists the sensitive species that have a potential to occur in the vicinity of the Parsons Complex. The Potential to Occur Onsite column in the table refers to the potential for each of these species to occur within the tidal portions of the Parsons Complex that are the focus of this restoration. Many of these species are not associated with tidal habitat and are not discussed in this section.

<u>Listed Species</u>

A total of 10 listed species have the potential to occur within the tidal portions of the Parsons Complex as presented below.

Tidewater Goby (*Eucyclogobius newberryi*) - Federal Endangered, California Species of Special Concern - The tidewater goby inhabits brackish to fresh water habitats along the California Coast from Tillas Slough (mouth of the Smith River) in Del Norte County, south to Agua Hedionda lagoon in San Diego County. Tidewater gobies range upstream a short distance into freshwater and downstream into water of up to about 75 percent sea water (28 parts per thousand) (USFWS 2004). The species typically is found in salinities of less than 12 parts per thousand (USFWS 2004). It is found in shallow lagoons and lower stream reaches where slow-moving or still, but not stagnant, water is found with high oxygen levels. Within Elkhorn Slough they have been found in Bennett Slough (Goggin 2002) and, in 2006, were collected in Moro

Cojo Slough (CNDDB 2007). Tidewater gobies are not known to occur in the Parsons Complex (Goggin 2002). The recent study by Ritter et al. (2007) of different tidal regimes in Elkhorn Slough only collected tidewater gobies at sites with minimal tidal flow. These sites were Crazy Cow in the Mojo Cojo Slough system and Struve Pond.

California Brown Pelican (*Pelecanus occidentalis californica*) – Federal Endangered, State Endangered. California brown pelicans were listed because of massive reproductive failure in the late 1960s to 1970s caused by the presence of DDT in their food chain**.** California brown pelicans nest on Anacapa and Santa Barbara Islands in southern California, off the Pacific coast of Baja California, Mexico and in the Gulf of California, Mexico. In summer, brown pelicans disperse from their breeding areas and many head north up the coast. They are common in the Elkhorn Slough area after their post-breeding dispersal. Many pelicans arrive during May and June with the greatest numbers present from July to October. They are common within the Parsons Complex. During bird surveys of South Marsh, about 10 brown pelicans were observed per survey (Fork 2004). Brown pelicans used the constructed islands in South Marsh for roosting, particularly during high tides.

Western Snowy Plover (*Charadrius alexandrinus nivosus*) – Federal Threatened, California Species of Special Concern. This small shorebird nests on coastal sandy beaches and the shores of salt ponds and alkaline lakes. They forage for insects and marine invertebrates in wet sand along the edge of the water. Snowy plovers nest at several areas along the beach near Moss Landing and in the Salt Ponds in Elkhorn Slough. They may forage on the mudflats in the Parsons Complex on occasion.

California Least Tern (*Sternula antillarum browni*) – Federal Endangered; State Endangered. The California least tern ranges from the San Francisco Bay area southward into South America. Least terns are present in California between mid-April and mid-September. They do not nest in Elkhorn Slough. The nearest nesting areas are in San Francisco Bay to the north and Oceano Dunes in San Luis Obispo County to the south. They are occasionally observed within the Parsons Complex during their migration (elkhornslough.org).

California Clapper Rail (*Rallus longirostris obsoletus*) - Federal Endangered State Endangered - California clapper rails are found in saltwater and brackish marshes traversed by tidal sloughs. They are associated with abundant growths of pickleweed but feed away from cover on invertebrates (CNDDB 2007). The historic range of the California clapper rail extended from Humboldt Bay southward to Elkhorn Slough and Morro Bay. Resident California clapper rail populations are currently limited to the San Francisco Bay system (LSA 2004). They were recorded in Elkhorn Slough in 1915 (Silliman, O.P. 1915), and again in 1972 between Kirby Park and Highway 1 (Varoujean 1972). They apparently have been extirpated as breeders in Elkhorn Slough. Recent surveys for rails in the Parsons Complex have not recorded clapper rails (K. Wasson, Personal Communication 2007).

American Peregrine Falcon (*Falco peregrinus anatum*) - State Endangered - Peregrine falcons are found in many open areas and nest on cliffs. The species declined in the 1960s and 1970s because of DDT-induced eggshell thinning and it was listed as endangered by the State and federal governments in the 1970s. The population has since recovered and peregrine falcons were de-listed by the federal government in 1999 but the species remains on the State endangered list. Peregrine falcons feed almost exclusively on birds. Coastal wetlands offer important foraging habitat for peregrine falcons because of the large congregations of shorebirds and waterfowl. Peregrine falcons are frequently observed in the Parsons Complex (elkhornslough.org 2007).

Southern Sea Otter (*Enhydra lutris nereis*) – Federal Threatened. The southern sea otter ranges from north of Año Nuevo Island in to Point Conception (USGS 2004). The 2007 spring sea otter survey counted 3,026 otters in California (USGS 2007). Approximately 70% of the California sea otter population occurs within the boundaries of the Monterey Bay Marine Sanctuary (Faurot-Daniels 1998). Sea otters are common in Elkhorn Slough including the Parsons Complex where pups have been born (Kieckhefer et al. 2004). The sea otter population in and offshore Elkhorn Slough has been studied by the Pacific Cetacean Group (Kieckhefer et al. 2004). The researchers found that the abundance of otters in Elkhorn Slough increased from a mean of 4.2 otters per survey in 1994 to 51.9 animals per survey in 1998. The mean for 2000 was 49, comparable to the 1998 count. There is no clear explanation for the dramatic increase in otter abundance within the Slough (Feinholz and Konopka-Reif 1996). However, sea otter abundance in Elkhorn Slough declined starting in 2001 and was only 4.8 otters per survey in Elkhorn Slough in 2004 (Kieckhefer et al. 2004). The decline in sea otters within Elkhorn Slough in 2001 correlated with an increase in otters in Monterey Bay, suggesting that otters may have shifted their habits to a higher use of offshore waters and lower use of the area within the Slough.

Sea otters in Elkhorn Slough feed primarily on Washington clams (*Saxidomus nuttalli*) gaper clams (*Tresus nuttalli*), fat innkeeper worms, and crabs (*Cancer* spp.) (Kieckhefer et al. 2004). The number of innkeeper worms in the otters' diet increased significantly in 2001 and crabs increased from 2001 through 2003. Between 1998 and 2003, the size of the clams consumed by otters shifted from medium-sized clams (< 5 cm) to either small (< 5 cm) or large (>10 to 20 cm) prey. The researchers suggested that benthic prey availability for otters may have decreased either from over-foraging by otters and/or from a change in substrate due to erosion. Sea otters regularly use the Parsons Complex especially Whistlestop Lagoon and the adjacent areas (K. Wasson, Personal Communication 2007).

Salmonids - Three listed species of salmonid occur in the waters of Monterey Bay. These are the Chinook salmon (*Oncorhynchus tshawatscha),* the Coho salmon *(O. kisutch*) and the steelhead (*O. mykiss*). The Coho salmon is federal threatened and State endangered and the steelhead is federal threatened. The winter run of the Chinook salmon is federal and State endangered and the spring run is State and federal threatened. The Chinook and Coho salmon do not breed as far south as Elkhorn Slough. Small runs of steelhead occur in the Pajaro and Salinas Rivers (Busby et al.1996). Although none of these salmon species would migrate through the Parsons Complex to breed, they might occasionally occur in the waters within the Complex.

Species of Concern/Other Sensitive Species

The California brackish water snail (*Tryonia imitator*) is a snail found in brackish waters of coastal lagoons and estuaries. It was formerly a Federal Species of Concern. In a recent study of sites with different levels of tidal exchange within Elkhorn Slough, the California brackish water snail was only found at four sites with minimal tidal exchange (Ritter et al. 2007). The sites where the California brackish water snail was found were Struve Pond, Lower Mojo Cojo, Porter Marsh and South Azevedo Pond. It was not found within the Parsons Complex.

Double-crested cormorants are a California Species of Special Concern that breeds along with great egrets and great blue herons in the rookery surrounding Rookery Pond at ESNERR. Double-crested cormorants began breeding at the rookery in 1997 and in 2004 had a high breeding population of over 110 nesting pairs (K. Wasson, Personal Communication 2007). The breeding population at the ESNERR rookery declined in 2005 and 2006, and only about 30 nests were found in 2007. Double-crested cormorants use the tidal areas of the Parsons Complex for foraging and roosting and are one of the most abundant birds counted in bird surveys of South Marsh (Fork 2004). Cormorants used the islands in South Marsh for roosting and were more abundant on the islands than the mudflats.

California gulls, a California Species of Special Concern, breed primarily at Mono Lake in California's interior. Recently a large nesting colony of California gulls has become established in the South San Francisco Bay salt ponds. This San Francisco Bay nesting population has increased from 12 nests in 1982 to over 33,000 nesting gulls in 2006 (SFBBO 2008). Long-billed curlews, a California Species of Special Concern, are a large shorebird with a down curved bill. Their breeding habitat is grasslands in west-central North America. California gulls and long-billed curlews are commonly observed in the Parsons Complex.

2.3.7.3. Habitat Assessment

A habitat assessment is provided below with consideration of numerous factors including subsidence, tidal muting, and erosion.

2.3.7.3.1. Subsidence and Loss of Salt Marsh

As described elsewhere in this document, the Parsons Complex has subsided due to diking and draining and most of the tidal area now is at an elevation too low to support salt marsh vegetation. Salt marsh vegetation currently is only present along the fringes of the tidal area and on the constructed islands in South Marsh. These islands are continuing to erode. Therefore, the small amount of salt marsh on the islands may eventually be lost. The lack of salt marsh in the Parsons Complex represents a loss in habitat diversity within the area. Furthermore, the paucity of salt marsh represents a loss of salt marsh functions. Salt marshes contribute nutrients to estuarine ecosystems and help to stabilize sediments and cleanse water of pollutants. Salt marsh areas also provide important refuge and roosting areas for water birds during high tides. Bird surveys of South Marsh documented that the islands were heavily used by birds especially during high tides (Fork 2004). The islands were major roosting areas for endangered brown pelicans and double-crested cormorants, a California Species of Special Concern.

2.3.7.3.2. Existing Mudflat and Channel Values

Although the Parsons Complex is suffering from the loss of diversity and function caused by a paucity of salt marsh habitat, the mudflats and channels have high habitat values that must be considered in restoration planning. The mudflat and channel areas support a diversity of fishes and tidal invertebrates. These provide a prey base for larger predators including water birds and sharks and rays.

Shark and ray use of the Parsons Complex is particularly noteworthy. Carlisle (2006) suggested that as the tidal creeks that branch directly off the Elkhorn Slough main channel have widened and deepened, they have lost their function as a nursery for sharks and rays. The Parsons Complex appears to have replaced the tidal channels off the main channel as the primary nursery habitat for leopard sharks.

The Parsons Complex also is important as a habitat for oysters. Wasson and Schmidt (2007) estimated that the Parsons Complex supports between 10 to 20 percent of the live oyster population in Elkhorn Slough.

Mudflats also provide habitat for fish spawning. The increase in mudflat habitat in recent years appears to have increased the overall abundance of fish larvae in Elkhorn Slough. Grannis (2006) documented a substantial increase in numerical abundance of total larvae, especially gobies, between 1985/86 and 1999/2000. The increase in the abundance of fish larvae may be related to a number of factors. The increase in the amount of mudflat habitat available for goby spawning appears to have resulted in increased larval production.

2.3.7.3.3. Muted Tidal Habitat Compared to Full Tidal Habitat

Whistlestop Lagoon consists of muted tidal habitat caused by the restriction of culverts. Studies of Whistlestop Lagoon compared to the full tidal habitat elsewhere in the Complex as well as other studies of numerous areas with restricted versus unrestricted tidal flow within Elkhorn Slough (Ritter et al. 2007) indicate that muted tidal areas support a fish assemblage similar to full tidal areas. However, Carlisle (2006), in his study of the movements of leopard sharks in

Elkhorn Slough, did not note them using Whistlestop Lagoon although they heavily used other portions of the Parsons Complex.

In a study of large mudflat invertebrates, fat innkeeper worms were found in South Marsh and not in Whistlestop Lagoon or other muted tidal sites within Elkhorn Slough (K. Wasson, Personal Communication 2007). Apparently, fat innkeeper worms need a full tidal range. Fat innkeeper worms are an important prey species for leopard sharks and also are eaten by sea otters. On the other hand several species of clam were more abundant in Whistlestop Lagoon than in South Marsh. The abundance of clams in Whistlestop Lagoon may be why this muted tidal area is heavily used by sea otters.

2.3.7.3.4. Current Land Management Practices

Because the Parsons Complex is owned by the California Department of Fish and Game and managed as a reserve, land management practices within the Complex are designed to preserve and increase habitat values to the extent possible. No land management practices were identified that are decreasing habitat values. No offsite land management practices were identified that are adversely affecting habitat values within the Parsons Complex.

2.3.7.3.5. Future Erosion

Continuing erosion will not only result in a continued loss of salt marsh within the Parsons Complex but also would be expected to degrade the existing mudflat and channel functions. Erosion within the main Elkhorn Slough channel and tidal creeks leading directly off the main channel has resulted in a widening and deepening of these channels and a coarsening of sediment. This erosion has resulted in a decrease in invertebrate diversity and a loss of nursery function. Erosion of the tidal creeks also apparently has resulted in a change in the fish assemblage from an estuarine community to an assemblage dominated by marine species (Yoklavich et al. 2002). The lower prey abundance in the channels, particularly of clams, may have resulted in a decrease in the use of Elkhorn Slough by sea otters (Kieckhefer et al. 2004).

The Parsons Complex now provides some of the functions (such as leopard shark nursery) previously provided by the main tidal creeks. However, these trends of loss of function seen in the main Elkhorn Slough Channel and tidal creeks, would be expected to occur within the Parsons Complex as erosion continues. It would be expected that continued erosion within the Parsons Complex would lead to a widening and deepening of the channels. As the channels widen and deepen and their sediments become coarser, they would be expected to support fewer invertebrates, particularly clams and they may loose their value as foraging and nursery areas. In addition, mudflat will be lost to continued expansion of the channels. The fish community in Long Valley already has changed from an assemblage characterized by estuarine species to marine species.

2.3.8. Sediment

A relative paucity of sediment-related information is available to characterize existing sediments within the Parsons Complex. Information is presented from the report prepared by Sea Engineering of geomorphology and other physical parameters at Elkhorn Slough that address soils in the Parsons Complex (Sea Engineering 2006), and a geotechnical investigation of soils by Kleinfelder Consultants (2002) for the UPRR bridge replacement project.

The geologic map of Monterey Bay by Wagner et al. (2002) labels geological deposits within the Parsons Complex as basin deposits (unconsolidated alluvial deposition from the watershed). Elkhorn Slough comprises a very thick layer (more than 500 meters thick) of sediment over deep bedrock. The surficial deposits in the region are composed of unconsolidated marine and non-marine gravel, sand, silt and clay deposits (Sea Engineering 2006). Research of soils in the Parsons Complex was done by Schwartz (1983). This work included sampling at two sites just east of the UPRR bridge along a slough channel shown in Figure 2-29. The samples were processed for grain size and age.

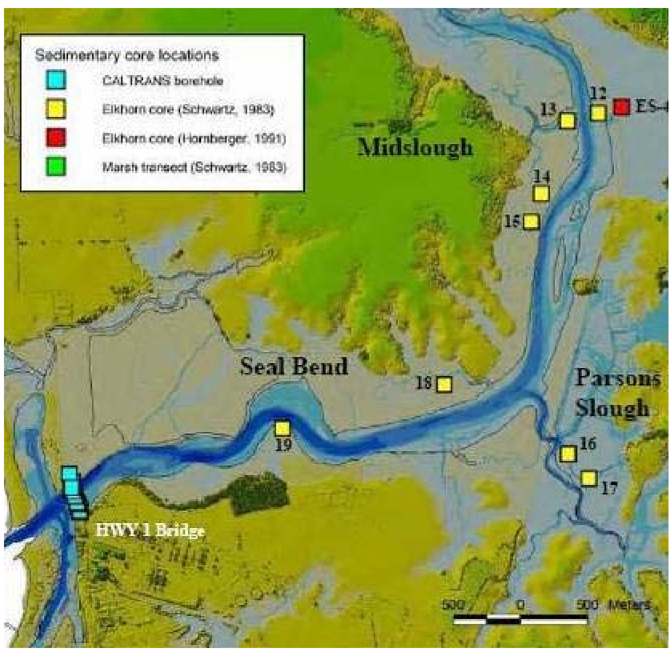


Figure 2-29 – Pertinent Soil Sampling Locations by Schwartz (1983) and Hornberger (1991)

Cores collected in the Parsons Complex have surficial deposits of coarse-grained fluvial gravel and sand, not organic layers of root mat or peat like cores taken from elsewhere within Elkhorn Slough. The core in the Parsons Complex that is closer to the tidal channel has a higher content of clay, while the core further away from the tidal channel (closer to the salt marsh plain) has a higher content of peat. Core 16 is close to the Parsons Slough tidal channel, penetrating a clay layer downcore of the coarse-grained surface deposit. Core 17 is farther away from the tidal channel and contains a 6.5 foot- (2 meter) thick layer of peat, before penetrating clay approximately 6.5 feet (2 meters) below the mean lower low water datum, which is 0.2 feet higher than 0 feet NAVD.

While no data are presented regarding the consolidation or strength of the sediments sampled in the cores, the ability to retrieve hand-cored sediment up to 23 feet (7 meters) deep within Parsons Complex suggests that the sediments are poorly consolidated and easily eroded by tidal currents present within the Slough (Sea Engineering 2006). Figure 2-30 shows the conceptual cross-section of the content of cores taken by Schwartz (1983) and Hornberger (1991) that include those at the Parsons Complex. The section indicates that soils in core 16, nearest the UPRR bridge at Parsons Slough, is fluvial sand and gravel (between 1,000 – 4,000 microns in grain size diameter) from the Slough bed down 2.5 feet (0.8 meters) below the surface, with clay (less than 3.9 microns in grain size diameter) below that down to a depth of 5 feet (1.5 meters) below the surface. Soils in core 17 that is located upstream into the Parsons Complex from the UPRR bridge is composed of fluvial sand and gravel over the top foot, and peat from approximately 1 foot to 3 feet (0.3 to 0.9 meters) below the Slough bed, and clay from 3 feet to 4.5 feet (0.9 to 1.8 meters) down into the core below the surface.

Inputs of sediment have decreased over time from the ocean, due to harbor installation and relocation of the mouth and from the Salinas and Pajaro Rivers when they were both modified and channelized (Sea Engineering 2006). Preliminary research using sediment coring techniques indicate that approximately 75% of the accumulated sediment is inorganic (mineral material) representing inputs from the watershed (Watson 2006.)

Scientists have observed a decrease in fine unconsolidated sediment along the main channel of Elkhorn Slough since the 1970s that likely has also occurred in the Parsons Complex (ESTWPT 2007). Areas near the mouth of the Parsons Complex increased by almost 9.8 feet (3 meters) in depth during the same period (Dean 2003, Malzone 1999). Sediments in the main Elkhorn Slough are decreasing in the proportion of fine-grained particles (silts and clays) in comparison to coarse-grained particles (sands and gravels) due to flow velocity increases and erosion of the finer-grained materials (ESTWPT 2007). This trend appears to also apply to surface sediments at the Parsons Complex from the Schwartz (1983) data.

Kleinfelder (2002) advanced two deep soil borings into sediments in the tidal channel approximately 40 feet west of the UPRR bridge. The borings were taken down to nearly 100 feet below ground, and identified two distinct depositional layers. In both borings the top layer is clayey silt from the surface down to 62 feet (19 meters) below ground, and the second layer is clayey sand from 62 feet to 89 feet (19 to 27 meters) below ground. The work also included two shallow holes excavated 1 foot below grade on marsh soils adjacent to the channel. No grain data are available from those holes.

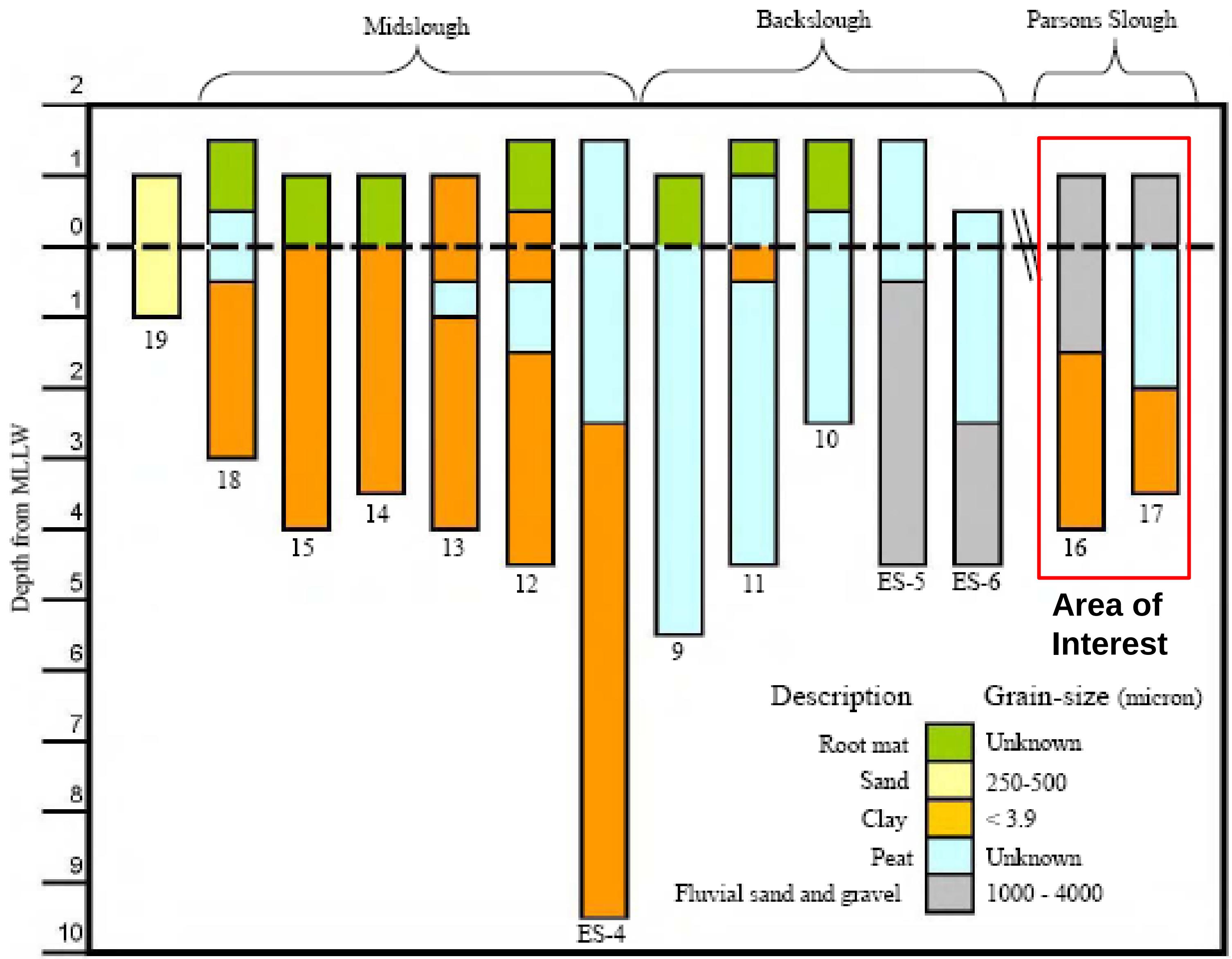


Figure 2-30 – Soil Profiles Throughout Elkhorn Slough by Schwartz (1983) and Hornberger (1991)

Kleinfelder (2002) also had the soil tested for contaminants and included samples from the shallow holes. Lab results indicate that soils deep in the profile (at 20 feet, 30 feet, 35 feet, and 45 feet below ground, respectively) contained metals at low levels that likely represent background concentrations. The deep and shallow (1 foot below ground) samples were also tested for pesticides and PCB's and none were detected.

2.3.9. Geomorphology

Geomorphology is important to understand for a project site because it links the existing three-dimensional surface with past and existing processes. Assuming that processes can be predicted into the future, this information is useful to understand how the site is likely to evolve over time, thus affecting habitat and restoration planning decisions. As previously mentioned in this report, the Parsons Complex is a relatively large tidally-influenced salt marsh that lies slightly lower than is needed to establish vegetated habitat areas. In fact, it is the largest area of former marshlands that has subsided within Elkhorn Slough (ESTWPT 2007). The main areas of the Complex are dominated by mudflat with subtidal creeks, fringing tidal marsh, and created tidal marsh islands.

2.3.9.1. Geomorphic Areas

While the Parsons Complex has subsided over time and has been significantly altered by man, it has retained naturally-evolved geomorphology throughout its southern portion, but possessed human-induced geomorphology throughout its northern portion. The geomorphology of the Parsons Complex is a hybrid condition of two very different areas shown in Figure 2-31. Both Slough geomorphic areas are described below.

2.3.9.1.1. Parsons Slough and Five Fingers

One geomorphic area within the Parsons Complex is a natural salt marsh within the southern two-thirds portion of the site, at Parsons Slough and the five fingers area. This more natural marsh is typified by dendritic channel patterns with approximately three stream orders within the channel pattern. Narrow tidal channels are incised within a large and flat marsh plain. The marsh plain is a depositional basin at the foot of the adjacent local watershed, with the surrounding upland area composed of foothills and tributary canyons. This southern portion of the Slough was diked over a period of time, and was drained and used for agricultural. It is subsided from its natural, pre-diked condition for reasons that are not entirely clear, but that probably relate to a combination of vegetation die-off and decomposition after diking, and erosion and sediment removal after re-opening. Less variation in elevation exists within the marsh plain of this more natural area as compared to the restored area of South Marsh to the north. Most of this site lies between 0 to +3 feet (0 and +1 meter) NAVD. Its eastern area is lowest in elevation.

Figure 2-31 – Geomorphologic Areas Within the Parsons Complex

2.3.9.1.2. South Marsh

The other major geomorphic area of the Parsons Complex is the northern one-third portion of the site comprising the restored area of South Marsh. A 1980s restoration project in South Marsh created channels, habitat islands, and reconnected tidal waters. Bank erosion has significantly decreased the width and length of these habitat islands since they were first constructed (ESTWPT 2007). As such, South Marsh is a man-made set of alternating channels and islands superimposed on a relic subsided marsh. The natural channel pattern is no longer recognizable in aerial photographs due to effects of diking, drying, and farming in the mid-1900s. In the historic aerial photograph of 1954, the site appears to have been leveled using some type of earthmoving equipment. Small drainage channels were retained on-site to remove storm runoff. The groundwater surface became gradually dewatered and compacted due to lower pore pressure existing in the soil than existed while the site was wetland, and as organic matter in the soil decayed and decomposed. Use by cattle resulted in weight being imposed on the surface and further settling.

In recent aerial photographs, the site still bears the scars of former farm features on-site, probably dikes and/or roads. Previous restoration actions consisted of dredging one main channel from near the UPRR bridge to Whistlestop Lagoon, with 19 short second-order tributary channels branching off of it at 90 degree angles. Mounds of material lie along both sides of the main channel, and along both sides of each tributary branch channel as small islands. In recent aerial photographs the islands resemble dashed lines along all channel areas. The mounds are areas of mid and high intertidal vegetated salt marsh habitat. The mounds are useful in that they lie at the appropriate elevation for the target salt marsh habitat of a future restored condition and therefore can be used as reference points for future concepts. This site possesses more variation in elevation within the marsh plan, with areas extending from 0 feet to +5 feet (0 to +1.52 meters) NAVD. It is lower in elevation in the north and east areas, similar to the five fingers area.

2.3.9.2. Geomorphic Processes

Geomorphic processes that have existed in the marshes over time and activities by man have influenced the site to be what it is today. Present-day processes continue to influence the marsh and will determine its future condition. Past and present geomorphic processes are summarized below.

2.3.9.2.1. Past Geomorphic Processes and Other Influences

Geomorphic processes and other major influences at the Complex are affected by human activities. These include diking off areas of Parsons Complex and draining them for various purposes, then modifying the Elkhorn Slough mouth which affected all upstream areas, and finally restoration of South Marsh that increased the tidal prism of Parsons Complex (and affected Elkhorn Slough).

Wetland Diking and Draining

Subsidence has occurred throughout all of the Parsons Complex over recent history (the last 135 years). Factors contributing to the subsidence include the effects of diking off the Parsons Complex from regular tidal inundation, beginning with construction of the railroad in the 1870s, the installation of duck hunting facilities in the early 1900s, and extensive reclamation for cattle pasture in the mid-1900s. Isolation from tides resulted in soil compaction, organic matter decomposition and loss, loss of sediment imported with regular tidal and storm flooding, and changes to water movement and storage (Cahoon et al. 1999). The draining of the tidal marsh areas in the Parsons Complex between 1931 and 1956 caused the marsh sediments to dry out, compact, decompose, and subside by several feet. In subsided areas where full or muted tidal flow has been returned, mudflats and lagoons have replaced historic vegetated salt marsh habitat (ESTWPT 2007). The eastern area of the Complex appears to be lower than the western portion.

Another result of diking is the decrease in natural sediment yield from the watershed over time. Diking significantly reduced the area connected to Elkhorn Slough that supplied sediment to the Parsons Complex during major floods on the Pajaro and Salinas Rivers. Coincident with and subsequent to some of the diking, these rivers were diverted/channelized and no longer supplied sediment to the Complex anyway, but localized diking by the railroad cut the Parsons Complex off from local sediment earlier in time, other than that delivered from Long Valley or other small tributary canyons.

Modification of the Elkhorn Slough Tidal Inlet

A significant geomorphic effect on all of Elkhorn Slough, including the Parsons Complex, was caused by installation of the Moss Landing Harbor entrance channel and jetties. This channel is maintained at navigable depths that are deeper than the original tidal inlet to Elkhorn Slough. The original tidal inlet formed a sill that acted as a dam, and limited the Slough bed elevations inland from the coast and controlled losses of sediment. The sill also controlled (truncated) the elevation of the low tide in the Slough and likely limited the tidal range to less than open ocean conditions, and correspondingly controlled habitat distributions.

Installation of the harbor channel, connection of the Slough to it, and deepening of the Slough ocean connection effectively lowered the sill in 1947 to the elevation of the new harbor channel. As such, bed sediments within Elkhorn Slough were vulnerable to loss to the deeper harbor area and offshore. Also, the tidal range was expanded to be that of the full ocean and the Slough's tidal prism increased, causing tidal flow velocities to increase. With sediment loss from the Slough bed, and increased tidal prism and flow velocities, head-cutting of the harbor navigation channel extended upstream into Elkhorn Slough, and into the tributary channels including the one connecting to the Parsons Complex entrance channel. The head-cutting has continued into Parsons deepening the entrance channel and causing gradual deepening of the channel network within the Complex and the surrounding tidal plan.

Restoration of South Marsh

Loss of sediment from the Parsons Complex has also occurred due to erosion following restoration of the South Marsh and Parsons Slough area in 1983. The project, by returning tidal circulation to 161 acres of South Marsh, increased the tidal prism by approximately 37%. This caused tidal flows under the UPRR bridge to significantly increase in discharge and velocity. These increased flow velocities eroded the channel under the bridge and added to the deepening of that portion of the channel system. Thus channel scour and head-cutting have deepened the main entrance channel, causing deepening of interior tidal channels and lowering of adjacent tidal marsh plan areas in response. The mouth of the Parsons Complex (just west of the UPRR bridge) increased in depth by almost 9.8 feet (3 meters) during the period from 1993 to 2001 (Dean 2003 and Malzone 1999), and to almost 16 feet (5 meters) in August 2002 (Broenkow and Breaker 2005). According to Dean (2003), the Parsons Complex has lost 60,000 cubic yards (46,000 cubic meters) of sediment between 1993 and 2001.

2.3.9.2.2. Present Geomorphic Processes and Influences

Present-day geomorphic processes and influences mainly relate to effects of the progressive down-cutting occurring throughout downstream areas at Elkhorn Slough. As presented in Sea Engineering (2006), the tidal entrances to both Elkhorn Slough and the Parsons Complex are not stable and are progressively deepening. The stability of a tidal entrance channel depends on the velocity of tidal flows through it over time and the erosive qualities of the soil material composing bed and sides of the cross-section.

The velocity of tidal flows is determined by the discharge of water passing through it over time and the size of the inlet cross-section. If the discharge of seawater passing through the cross-section is relatively high and flow velocities swift, the cross-section erodes and enlarges to convey the discharge with lower velocities. As the cross-section enlarges, the flow velocities decrease while the discharge remains constant (the same amount of water is passing through the cross-section but at a slower speed). Conversely, if the discharge of seawater passing through the cross-section is relatively low and flow velocities slower, the cross-section accretes and becomes smaller to compensate. As the cross-section constricts, the flow velocities increase while the discharge remains constant. This can be shown graphically using an Escoffier plot (Escoffier 1977). In natural systems, the cross-section becomes an equilibrium size and shape to pass the tidal discharge without significant erosion or accretion over time, but it constantly adjusts in a dynamic condition to the tidal discharge.

Analyses of inlet stability were performed by Sea Engineering (2006) for both the Elkhorn Slough entrance channel and the Parsons Complex entrance channel. Their analyses clearly show that the entrances at both Elkhorn and the Parsons Complex are unstable, meaning they are progressively enlarging because their tidal flow velocities (caused by tidal discharges) are too high for their cross-sectional areas. Both entrance channels are unable to expand in width due to bridge constraints, and can only deepen to enlarge. As they deepen, they cause head-cutting and erosion of wetland areas upstream that consequently increases the tidal prism. They cannot enlarge enough to reach an equilibrium condition with regard to tidal flow velocity, and therefore continue deepening, thus progressively increasing their tidal prisms at the same time and causing a positive feedback loop. The Parsons Complex entrance would have to increase by approximately 1.5 times in cross-section area to reach an equilibrium condition (Sea Engineering 2006). Sea Engineering concludes that without decreasing the tidal prism, tidal flow velocities will continue to increase perpetuating the problem of inlet scouring.

The unstable condition of the Parsons Complex entrance channel is unable to be rectified short of significantly expanding the channel width as well as its depth under the UPRR bridge, and/or reducing tidal flow velocities by reducing the tidal prism. This fact may be one of the most significant project constraints identified thus far, and may dictate the approach taken to restoration. Restoring the Parsons Complex may require reduction of its tidal prism to halt channel and marsh scour and allow sediment to accrete throughout the site to increase the bed elevations sufficiently to establish vegetated marsh habitat.

The present result of previous and existing geomorphic processes on the site is a marsh with an extremely narrow and deep gorge entrance channel, broad and low flanking marsh plains, and a general trend of being slightly lower in formerly diked areas in South Marsh and the five fingers than in the western portion of the Complex. Figure 2-32 shows site morphology. Visible in the image is a relatively higher marsh plain near the UPRR tracks in the western project area, and lower elevations toward the east and north, farther into the Complex from the entrance channel. Site morphology may dictate the appropriate restoration approaches and will be considered in subsequent restoration tasks.

2.4. Data Gaps

Significant data gaps are few and do not substantially constrain or limit the completion of feasibility-level studies that are occurring as part of this wetland restoration planning effort phase. However, future phases will eventually be constrained by limitations of the data and additional data should be acquired. The next phase of work will be completion of environmental review and permitting. Existing data are generally adequate to support those tasks, with the possible exception of one data set described below, along with those that exist for final engineering.

2.4.1. Planning-Level Data Gap

One possible data gap exists as presented below that should be addressed during this project planning phase.

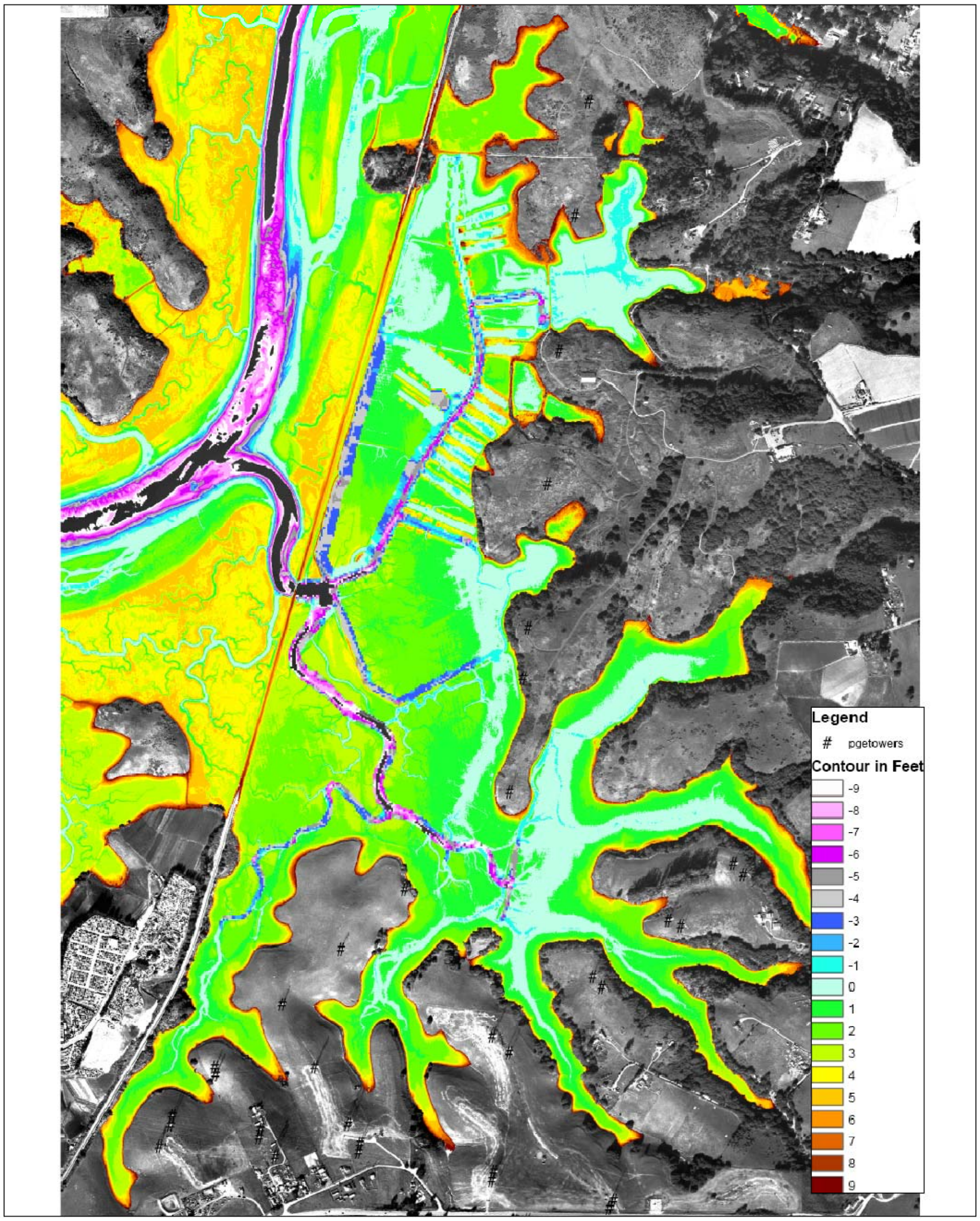


Figure 2-32 – Morphology of the Parsons Complex

2.4.1.1. Circulation Patterns And Velocities Throughout The Marsh Over A Spring Tide Cycle

Data of tidal circulation patterns and flow velocities throughout all areas of the Parsons Complex have not been recorded in a comprehensive fashion. Circulation patterns and flow velocities throughout the Complex could be recorded to calibrate models and inform restoration designs. These data can be obtained by performing drogue studies such as those performed for other recent projects (i.e., Malibu Lagoon, Huntington Beach Wetlands, and Cabrillo Marsh). An inexpensive drogue study can be performed by monitoring and timing the movement of marked (numbered) organic floats (e.g., oranges) throughout the marsh that are released at the UPRR bridge during a rising spring tide. Floats can be tracked throughout the marsh through the rising, and subsequent falling tide, to gage the general circulation patterns throughout the marsh and estimate flow velocities in more distant areas. Due to the large area of the Parsons Complex this work would be labor-intensive and require several staff (up to 10-12) in kayaks and on-shore to execute. Volunteers would be suitable for this task with oversight by a person (or persons) experienced with this work. A rough cost estimate range to complete this task is approximately from $20,000 maximum with all paid staff to $6,000 if all but two staff were volunteers.

2.4.2. Final Engineering-Level Data Gaps

Certain types of new data should be obtained prior to initiating the phase of final engineering for construction so that construction-level designs can be prepared to the level of accuracy needed to minimize changes during construction and associated additional costs. Gaps in existing data that should be filled prior to moving on to the final engineering phase include those described below.

2.4.3. Topography/Bathymetry Data

Topography/bathymetry data are needed for subtidal channels at Whistlestop Lagoon and the Rookery Lagoon. These areas were underwater during the most recent LIDAR survey. They were not covered by the survey and should be recorded using standard bathymetric survey techniques to define bed depths and geometry. Survey data will likely be cross-sections of these areas taken at an appropriate water level condition as determined by the surveyor and/or engineer. A cost estimate to perform this work should be obtained from a licensed surveyor and may be between $5,000 and $10,000.

Due to the existing condition of scour throughout tidal channels in the Parsons Complex another bathymetric survey of primary channels may be needed between approximately 2010 and 2015 to update the project site base map prior to engineering and construction of a project. The cost of that work may be in the range of between $15,000 and $25,000 and should be performed by a licensed surveyor for calculation of quantities for construction.

2.4.3.1. Flow Velocities At The UPRR Bridge

Flow velocities reflect the processes of scour and deposition. Estimates of existing flow velocities have been recorded at the UPRR bridge over time, but should be recorded again to quantify present/future conditions. A flow velocity meter, such as an Acoustic Doppler Current Profiler (ADCP), can be moored on the channel bed to obtain these data. The cost to perform this work is approximately between $50,000 to $75,000 if done by consultants at present rates including gage installation and retrieval, gage rental, data reduction and analysis, and reporting. It can likely be done less expensively using volunteers or students from regional academic and research institutions.

2.4.3.2. Discharge Estimates At The UPRR Bridge To More Accurately Determine The Existing Tidal Prism

The two data gaps identified above (channel surveys and flow velocities at the UPRR bridge) can be used together to accurately estimate the tidal discharge to and from the Parsons Complex during a mean and spring tidal conditions. This tidal discharge represents the tidal prism at the Parsons Complex. Data required for this estimate are a detailed bathymetric survey of the channel cross-section at the location of the current meter instrument, and water level and flow velocity readings from the instrument throughout a tide cycle. The cost for this task is mostly covered by the previous two tasks. However, additional costs are required to estimate the tidal prism and are roughly estimated to be between $2,500 and $5,000 for all analysis and a letter report.

2.4.3.3. The Geotechnical Integrity Of The Whistlestop Levee

Observations show that the levee between South Marsh and Whistlestop Lagoon is sinking and deforming. Assessment of the levee's stability and integrity should eventually occur to understand the probability of ultimate failure and the need for any maintenance, repair, or removal actions. The cost of this work should be determined from a qualified geotechnical engineer but costs for similar recent work were approximately between $50,000 to $75,000, depending on the type of equipment and methods to be used.

2.5. Conclusions and Recommendations

Available data were reviewed to characterize existing site conditions at the Parsons Complex and to identify any data gaps. Both are summarized below.

2.5.1. Existing Conditions

The Parsons Complex is characterized by the following conditions:

1. Several structures and certain utilities exist within the Parsons Complex that should be considered as possible opportunities and/or constraints for restoration. Structures include the UPRR bridge, the Reserve Bridge, levees along the UPRR right of way, at Whistlestop Lagoon, and the Rookery Lagoon, and culverts to Whistlestop Lagoon. Utilities include several overhead power lines with supporting power poles through and around the Complex.

2. The site is mainly in public ownership that is conducive to restoration. Several private property owners do possess land in the most distant portions of two of the five fingers, so restoration planning should consider possible constraints of ownership and impacts to property.

3. Existing site topography and bathymetry is lower than that at a typical vegetated salt marsh. Elevations of the marsh plain are approximately 2 to 3 feet (0.6 to 0.9 meters) below those that need to exist for colonization by salt marsh vegetation.

4. Tidal elevations are similar to those in the open ocean. Tidal elevations are essentially those of a full tidal system, and tidal lag times are minimal throughout the Complex as compared to Elkhorn Slough. The exception to this condition is Whistlestop Lagoon which has a muted tide range (approximately 1.5 feet) and lags approximately 4 to 5 hours behind the tide at the UPRR bridge.

5. The tidal prism of the Parsons Complex was estimated to be between 60 to 85 million cubic feet (1.7 and 2.4 million cubic meters) in 2002, up from 49 cubic feet (1.4 million cubic meters) in 1987. These volumes represent approximately 21% to 37% of the total tidal prism of Elkhorn Slough.

6. Tidal flow velocities are relatively high at the UPRR bridge and undocumented elsewhere. Maximum velocities at the bridge are on the order of 5.6 feet per second (1.7 meters per second) on ebbing tides and 4.9 feet per second (1.5 meters per second) during flooding tides. These velocities are sufficient to erode sediments from the channel.

7. Tidal inundation frequency within the Parsons Complex is equivalent to that within full tidal salt marshes. Vegetated salt marsh habitat will colonize at appropriate elevations ranges relative to tidal elevations if tides remain as they presently exist without being modified. Modifying the tides could result in modification to habitat elevations, and this process should be considered if restoration includes tidal muting.

8. Sea level rise throughout the future is estimated to be 2.2 feet per century (7 mm per year) by 2050, with continued acceleration. The sea level in 2050 is projected to be 0.9 feet (0.27 meters) above the level in 1990. This trend needs to be considered in designs for restoration alternatives.

9. Direct storm runoff to the Parsons Complex comes mainly from Long Valley. Long Valley is a small tributary that contributes relatively small volumes of freshwater over time and thus has a minimal and temporary effect on water quality conditions in the Complex.

10. Water quality in the Parsons Complex is relatively good compared to other areas of Elkhorn Slough and is typical of that for salt marshes in moderately populated and agricultural areas. Water temperature, salinity and pH are at standard levels with

seasonal variations throughout the year. Nutrients tend to vary according to season with high levels in winter/spring from storm runoff events, and appear to cause algal blooms in spring. Algal blooms or high levels of primary production cause dissolved oxygen levels to rise to levels of supersaturation in the day, then plummet to anoxic conditions at night. These conditions are short-term and stress the habitat, but do not seem to cause significantly adverse conditions to fish. Possible exacerbation of this condition should be considered in any restoration approach that includes tidal muting.

11. The channels and mudflats of the Parsons Complex are considered to be high quality habitat, particularly in light of degrading conditions in Elkhorn Slough. The site serves the important role of providing nursery habitat for juvenile fish. Vegetated intertidal habitat is degrading and of relatively poor quality compared to typical salt marshes. The site is home to certain sensitive and endangered species. The habitat conditions in the Parsons Complex are summarized as follows:
    a. Most of the salt marsh in the Parsons Complex has been lost resulting in a loss of diversity and salt marsh functions (roosting, foraging and shelter for birds, sediment stabilization, nutrient production, water cleansing);
    b. Salt marsh continues to erode threatening the existing functions;
    c. Subtidal channels and intertidal mudflats support a diversity of tidal invertebrates and fishes that provide a prey base for larger predators;
    d. The Parsons Complex is heavily used by sharks and rays for foraging and as a nursery;
    e. The Parsons Complex supports between 10 to 20 percent of the live oyster populations in Elkhorn Slough;
    f. Continuing erosion would be expected to widen and deepen the channels in the Parsons Complex at the expense of mudflat; and
    g. Continuing erosion would be expected eventually to degrade the habitat function of the channels and mudflat in the Parsons Complex as has happened elsewhere in Elkhorn Slough.
12. Sediment is typified by soft silts in a very thick layer in areas sampled near the main tidal channel. Data were not available for the entire marsh. Available data indicate that surface sediments are very fine and do not possess contaminants. A deep layer of sand exists at approximately 60 feet or more below the existing ground surface.

13. Existing geomorphology indicates that the site is subsiding slowly due to various factors, including head-cutting of the main entrance channel, increased tidal prism and consequent erosion, residual effects of former diking/draining/farming, and reduced inputs of sediment from the watershed. This trend is projected to continue over the long-term and is not expected to diminish or decline in the near future without man-induced intervention.

2.5.2. Data Gaps

Certain data gaps do exist and should be filled prior to completing final engineering, with one possible gap that could be filled prior to the completion of conceptual planning as listed below:

6. Conceptual planning phase -- comprehensive circulation monitoring event using floats.

7. Final engineering phase:

    a. Bathymetric surveys of Whistlestop Lagoon and the Rookery Lagoon;
    b. Bathymetry of all subtidal channel areas including the channel under the UPRR bridge, the main tidal channels should occur again by 2015 to record changes from existing surveys to monitor bed scour;
    c. Measurement of tidal currents under the UPRR bridge;
    d. Estimation of the tidal prism of the Parsons Complex from calculation of the tidal discharge at the UPRR bridge; and
    e. Geotechnical investigation of the levee at Whistlestop Lagoon.

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APPENDIX 2-A- BIOLOGICAL SPECIES LIST AT THE PARSONS COMPLEX

Scientific Name	Common Name	Status	Habitat	Potential to Occur Onsite*
INVERTEBRATES				
Class Gastropoda				
Tryonia imitator	Mimic tryonia (California brackish water snail)	Fed: -- CA: -- CDFG: --	Coastal lagoons, estuaries, and salt marshes in permanently submerged areas in a wide range of sediment types and salinities.	Low
Class Insecta				
Coelus globosus	Globose dune beetle	Fed: -- CA: -- CDFG: --	Coastal sand dunes, dune vegetation; foredunes and sand hummocks; burrows beneath the sand surface and beneath dune vegetation.	Absent
FISHES				
Class Osteichthyes				
Oncorhynchus kisutch	Coho salmon – central California ESU	Fed: FE CA: SE CDFG: --	Anadromous; breed in Northern California and further north.	Moderate
Oncorhynchus mykiss irideus	Steelhead – south/central California coast ESU	Fed: FE CA: -- CDFG: CSC	Anadromous; major rivers in central California; returns to natal streams and rivers to spawn.	Moderate

Scientific Name	Common Name	Status	Habitat	Potential to Occur Onsite*
Oncorhynchus tshawytscha spring-run	Spring-run Chinook salmon	Fed: FT CA: ST CDFG: --	Anadromous; major rivers in central California; migrate into headwaters in February through July and hold in pools until they spawn; breed in central valley.	Moderate
Oncorhynchus tshawytscha winter-run	Chinook salmon winter-run	Fed: FE CA: SE CDFG: --	Anadromous; major rivers in central California; breed in central valley.	Moderate
Eucyclogobius newberryi	Tidewater goby	Fed: FE CA: -- CDFG: CSC	Brackish water habitats, shallow lagoons and lower stream reaches with still, but not stagnant, water and high oxygen levels.	Low
AMPHIBIANS				
Class Amphibia				
Ambystoma californiense	California tiger salamander	Fed: FT CA: -- CDFG: CSC	Annual grasslands and grassy understory of valley-foothill hardwood habitats; need underground refuges, especially ground squirrel burrows and vernal pools or other seasonal water sources for breeding.	Absent

Scientific Name	Common Name	Status	Habitat	Potential to Occur Onsite*
Ambystoma macrodactylum croceum	Santa Cruz long-toed salamander	Fed: FE CA: SE CDFG: FP	Wet meadows, coastal woodlands and chaparral near the ponds and freshwater marshes; breeds in shallow, temporary freshwater ponds, both natural and human-made.	Absent
Anniella pulchra nigra	Black legless lizard	Fed: -- CA: -- CDFG: CSC	Sand dunes and sandy soils with bush lupine and mock heather as dominant plants; moist soil is essential.	Absent
Rana aurora draytonii	California red-legged frog	Fed: FT CA: -- CDFG: CSC	Lowlands and foothills in or near permanent sources of water, including cattail and tule marshes, reservoirs, ponds, and streamsides; prefers deep, still, or slow moving water with low salinity levels and shallow margins or riffle zones; must have access to estivation habitat.	Absent
Clemmys marmorata	Western pond turtle	Fed: -- CA: -- CDFG: CSC	Ponds, marshes, rivers, streams and irrigation ditches with aquatic vegetation; need basking sites and suitable upland habitat for egg-laying (i.e., sandy banks or grassy open fields).	Absent

Scientific Name	Common Name	Status	Habitat	Potential to Occur Onsite*
Clemmys marmorata pallida	Southwestern pond turtle	Fed: -- CA: -- CDFG: CSC	Permanent or nearly permanent bodies of water in many habitat types; requires basking sites, such as partially submerged logs, vegetation mats, or open mud banks.	Absent
BIRDS				
Class Aves				
Pelecanus occidentalis californica	California brown pelican	Fed: FE CA: SE CDFG: --	Pelagic; beach and nearshore waters; day roosts on area beaches.	High
Phalacrocorax auritus	Double-crested cormorant (rookery site)	Fed: -- CA: -- CDFG: CSC	Aquatic habitats, such as lakes, artificial impoundments, slow-moving rivers, lagoons, estuaries, swamps, seacoasts, and coastal cliffs; colonial nester, typically nests on the sloped grounds of coastal cliffs, offshore islands, or in the tall trees at the margins of lakes when inland.	High

Scientific Name	Common Name	Status	Habitat	Potential to Occur Onsite*
Falco peregrinus anatum	American peregrine falcon	Fed: Del CA: SE CDFG: FP	Rolling foothills and valley margins with scattered oaks and river bottomlands or marshes next to deciduous woodland; open grasslands, meadows, or marshes for foraging close to isolated, dense-topped trees for nesting and perching.	High
Rallus longirostris obsoletus	California clapper rail	Fed: FE CA: SE CDFG: FP	Saltwater and brackish marshes traversed by tidal sloughs; associated with abundant growths of pickleweed, but feeds away from cover on invertebrates from mud-bottomed sloughs.	Low
Charadrius alexandrinus nivosus	Western snowy plover	Fed: FT CA: -- CDFG: CSC	Nests on barren to sparsely vegetated sand beaches, dry salt flats in lagoons, dredge spoils deposited on beach or dune habitats, levees and flats at salt-evaporation ponds, and river bars; in California, most breeding occurs on dune-backed beaches, barrier beaches, and salt-evaporation ponds, and infrequently on bluff-backed beaches.	Moderate

Scientific Name	Common Name	Status		Habitat	Potential to Occur Onsite*
Numenius americanus	Long-billed curlew	Fed: CA: CDFG:	-- -- CS C	Sandy beaches, salt pond levees and shores of large alkali lakes; sandy, gravelly or friable soils for nesting.	High
Larus californicus	California gull	Fed: CA: CDFG:	-- -- CS C	Open water, mudflats, and salt panne.	High
Sternula antillarum browni (formerly *Sterna antillarum browni)*	California least tern	Fed: CA: CDFG:	FE SE FP	Nearshore beaches; bare or sparsely vegetated, flat substrates, such as sandy beaches, alkali flats, land fills, or paved areas.	Moderate
Asio flammeus	Short-eared owl	Fed: CA: CDFG:	-- -- CS C	Swamp lands, both fresh and salt; lowland meadows; irrigated alfalfa fields; tule patches, tall grass needed for nesting and daytime seclusion, nests on dry ground in depression concealed in vegetation.	Low

Scientific Name	Common Name	Status	Habitat	Potential to Occur Onsite*
Athene cunicularia	Burrowing owl	Fed: -- CA: -- CDFG: CSC	Open, dry annual or perennial grasslands, deserts and scrublands characterized by low-growing vegetation; subterranean nester, dependent upon burrowing mammals, most notably, the California ground squirrel.	Low
Riparia riparia	Bank swallow	Fed: -- CA: ST CDFG: --	Riparian and other lowland habitats; requires vertical banks/cliffs with fine-textured/sandy soils near streams, rivers, lakes, or ocean to dig nesting hole.	Low
MAMMALS				
Class Mammalia				
Enhydra lutris	Southern Sea Otter	Fed: Threatened CA: CDFG: Fully Protected	Shallow nearshore waters with rocky or sandy bottoms that support large populations of their benthic invertebrate prey (Aspen 2005).	

* potential to occur on site only addresses tidal habitats

Source: California Natural Diversity Data Base 2007, Department of Fish and Game Special Animals October 2007

FE = Federally Endangered; FT = Federally Threatened

SE = State Endangered; ST= State Threatened; FP = Fully protected; CSC = California Species of Special Concern

CHAPTER 3

ANALYSIS OF ALTERNATIVES

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

ANALYSIS OF ALTERNATIVES

3.1. Chapter Summary

Alternatives were evaluated that advance the three goals of the Parsons Slough Project: to restore tidal salt marsh in Parsons Slough, to restore the processes that sustain tidal marsh and soft subtidal habitats in the Elkhorn Slough estuary as a whole, and to do so while preserving high quality existing habitat in Parsons Slough. Restoration planning is occurring concurrently for the main Elkhorn Slough channel, and actions at the Parsons Complex need to be compatible with actions at the main Elkhorn Slough channel. This Report addresses restoration alternatives at the Parsons Complex. This analysis of restoration alternatives for the Parsons Complex conveys results of analyses of three basic wetland restoration alternatives, with several subalternatives included. The alternatives include:

- No Project – Existing conditions are maintained.
- Alternative 1 – A high water control structure (+9 feet North American Vertical Datum, or NAVD) with culverts and tide gates in the main Parsons entrance channel attached to the Union Pacific Railroad (UPRR) Bridge levee to arrest channel scour, mute tides and lower mean water levels; subalternatives consist of filling lower areas of the Complex behind internal dikes (without further muting).
- Alternative 2 – A subtidal sill (with the crest at -2 feet NAVD) in the main Parsons entrance channel downstream of the UPRR Bridge and levee to arrest channel scour and contain sediment within the Complex, coupled with sediment additions at large and/or small scales behind internal dikes (without muting).
- Alternative 3 – Internal dikes to contain sediment additions to the Complex and either equipped with culverts and tide gates to enable tidal muting to varying degrees (from extreme to moderate) that can be modified or adapted over time, or connected with gaps in the containment dikes at the locations of existing channels to eliminate muting.

The project recommended for implementation at the time of this writing, the Parsons Slough Sill, includes elements of both Alternatives 1 and 2. It consists of a high water control structure on the sides of the channel (+8 feet NAVD), a subtidal sill at the center (-5 feet NAVD), and with an adjustable section in between. No sediment additions were included in this recommended project. This project is highly feasible and achieves Goals 2 and 3 (restore estuarine processes while preserving high quality existing habitat), but is expected to only marginally advance Goal 1 (restore salt marsh in Parsons Slough). This project is discussed in detail in Chapter 4. Chapter 4 also discusses future actions to continue the assessment of elements evaluated in this chapter, particularly the large scale addition of sediment to restore tidal salt marsh in subsided areas.

For Alternatives 1, 2 and 3 analyses were performed for:

- Tidal Hydrology and Hydraulics
- Water Quality
- Sea Level Rise
- Habitat Changes
- Potential Impacts to the Railroad Levee and Related Structures
- Maintenance Requirements
- Estimated Construction Costs
- Preliminary Environmental Review
- Compatibility with Future Sediment Additions and/or The Larger Elkhorn Slough Project
- Consistency with Project Goals and Objectives

Results for each alternative are summarized below. Analyses were required to be performed for conditions at 5 years and 20 years after implementation.

No Project – The No Project offers little long-term benefit to the site. It preserves existing habitat conditions and processes on-site, and prevents disturbance to the site from construction operations. Yet it precludes restoration actions to offset losses of salt marsh, and proactive measures to anticipate sea level rise. The site will eventually transition completely to a subtidal basin, with a larger tidal prism to increase the scour and marsh loss within Elkhorn Slough. This alternative is not consistent with project goals and objectives.

Alternative 1 – This alternative halts the basic problem of entrance channel tidal scour and consequent sediment loss from the marsh. It also immediately reduces the tidal prism, results in salt marsh habitat creation over the short-term, and requires minimal to no near-term sediment additions for restoration. However, the tide control structure is complex and requires intensive maintenance and management to function properly. It is technically feasible to lower tide levels to create habitat and theoretically still allow only the highest water levels to equalize along both sides of the UPRR line. However, tide-control structures are rarely problem-free and the consequences of any performance failure at this site are serious and could lead to the highest water levels not equalizing on both sides of the UPRR line. The UPRR will have to permit this structure as it will connect with the UPRR levee. Habitat created will be extensive in area, but diversity will be less compared to full tidal systems. The structure is a partial barrier to passage of some fishes and marine mammals.

Various combinations of culverts and tide gates can be included in the water control structure to allow for some measure of adaptive management to anticipate sea level rise, but maintaining target tidal elevations over the very long-term future (100 years) with sea level rise may not be possible without challenges. Tidal flushing will not be adequate to maintain high water quality, particularly in the summer season. There is currently a decision-making process underway that entails actions in the larger Elkhorn Slough. This alternative is consistent with future actions to be taken in the main Elkhorn Slough channel that do not raise the elevation of the low tide (high tide muting is potentially acceptable) or raise the elevation of Elkhorn Slough bed. This alternative is lower in construction costs compared to the other alternatives.

Alternative 2 – This alternative also solves the primary problems of entrance channel tidal scour and resultant sediment loss from the marsh. It does not immediately reduce the tidal prism, nor result in salt marsh habitat creation over the short-term unless sediment is added as fill. Alternative 2 assumes sediment is added for restoration either incrementally or at a large-scale. The sill structure is simple and requires minimal maintenance and repair. The sill can be separate from the (UPRR) bridge, and sediment will likely deposit around UPRR bridge piles to increase their stability. Habitat created over the long-term will be extensive in area, and diversity would be that of a full tidal system. The sill still allows passage of most fishes and marine mammals.

The sill can be raised as an adaptive management measure to anticipate sea level rise, and sediment would have to be continually added in the future to maintain habitat by keeping pace with water levels. Tidal flushing would be similar to existing conditions. This alternative is also compatible with future actions to be taken in as part of the larger Elkhorn Slough restoration project that do not lower the elevation of the high tide (high tide muting would not be compatible). If high tides were muted at Elkhorn (and lowered similar to the proposed Alternative 1 at Parsons) and sediment were added at Parsons under Alternative 2 to raise the wetland surface elevation, the elevation of Parsons could be too high relative to the tides in Elkhorn to support salt marsh habitat and the site could transition to upland. This alternative costs more than the other alternatives to implement over the long-term.

Alternative 3 – This alternative does not address the problems of entrance channel tidal scour and associated sediment loss from the marsh. However, Alternative 3 immediately reduces the tidal prism, results in salt marsh habitat creation over the short-term, and could require minimal to no near-term sediment additions for restoration. The tide control structures will require regular maintenance to function properly but consequences of failure are less consequential compared to the structure of Alternative 1. The UPRR would not have to participate in this project as all actions are separate and independent of their infrastructure. Habitat created will be extensive in area, but diversity will be less compared to full tidal systems. The tide control structures will be partial barriers to passage of some fishes and marine mammals.

The operation of tide gates can be modified for adaptive management to anticipate sea level rise, but maintenance of targeted tidal elevations may be difficult to achieve over 20 years of sea level rise (required for analysis in the scope), and may not be feasible over the long-term (100-year) future. Tidal muting would lead to reduced flushing and impaired water quality in the summer season. As with Alternative 1, this alternative is consistent with future actions to be taken in the main Elkhorn Slough channel that do not raise the elevation of the low tide or raise the elevation of Elkhorn Slough bed. If the Elkhorn Slough low tide elevation or bed were raised, the marsh surface and water levels in muted areas in Parsons would have to be raised accordingly. This alternative is intermediate in cost to implement over the long-term between the other alternatives.

This alternative could lead to loss of marsh in the main body of the Parsons Complex over time. As such, the long-term benefits of this action are limited compared to those of the other alternatives, yet it can provide short-term improvements by tidal muting and/or filling at the fingers with a less costly initial investment. This alternative could serve as a set of short-term actions if funding is limited that could be supplemented with a larger action of a structure or sill at a later date if more funding becomes available.

The Parsons Restoration Team requires key information for further decision-making. Information gaps include:

- Effectiveness of the sill near (just downstream of) the UPRR bridge;
- Refinement of fill placement cost estimates;
- Costs/benefits analyses of alternatives;
- The status of muting as an option; and
- Appropriate restoration habitat distributions.

3.2. Introduction

Using the project goals, existing conditions, and sediment addition analysis (Appendix 3-1), restoration alternatives were developed and analyzed.

As described in Chapter 1, the guiding goals were:

Goal 1: To restore and enhance intertidal marsh habitats and functions within the Parsons Slough tidal wetland complex while addressing the needs of special-status species, estuarine-dependent species, and ongoing human uses.

Goal 2: To support the ecological recovery of the larger Elkhorn Slough system to the extent possible while meeting Goal 1.

Goal 3: To conserve high quality subtidal and intertidal estuarine habitats and functions within the Parsons Slough tidal wetland complex.

Existing data indicate that the Parsons Complex is significantly lower in elevation than conditions required for establishment of vegetated salt marsh. As a result, this wetland mainly consists of mudflat areas with subtidal channels, and small areas of vegetated marsh along its perimeter and on isolated islands. The existing conditions report also detailed significant changes in Parsons' tidal prism over time. The tidal prism of the Parsons Complex was between 60 to 85 million cubic feet (1.7 and 2.4 million cubic meters (mcm)) in 2002, up from 49 million cubic feet (1.4 million cubic meters) in 1987. These volumes are 21% and 37% of the total tidal prism of Elkhorn Slough. Tidal flow velocities at the UPRR bridge are approximately 5.6 feet per second (1.7 meters per second) on ebbing tides and 4.9 feet per second (1.5 meters per second) during flooding tides. These velocities are sufficient to erode sediments from the channel.

The sediment addition analysis revealed that approximately 2.3 million cubic yards of sediment needs to be added to raise Parsons to the elevation suitable for large-scale colonization of vegetated salt marsh across the entire site (except for tidal channels). Sediment sources exist within the region both upland offshore. Upland sources include materials both within and outside of the watershed. Sources include lakes, agricultural farms, regional road right of ways, development sites, flood control facilities, and quarries. Aqueous sources include local harbors and navigable waterways, the near shore ocean, and the offshore ocean. A promising source appears to be a local quarry accessible by truck and rail.

Using this information, the Parsons Restoration Team and Strategic Planning Team identified alternatives for restoration. This chapter describes the alternatives and provides analyses sufficient for selection of the preferred alternative.

3.3. Description of Alternatives

A total of four alternatives are analyzed for their effectiveness at restoring wetlands at the Parsons Complex. Alternatives include No Project and three scenarios of restoration actions varying from muting the entire site (Alternative 1), filling the entire site (Alternative 2), to a hybrid of diking, filling, and possibly muting at the fingers only (Alternative 3). Restoration Alternatives 1 – 3 include subalternatives of placing fill in the fingers. Table 3-1 shows a list of alternatives and subalternatives. Each alternative is described below.

Table 3-1 – Proposed Project Restoration Alternatives

Basic Restoration Alternatives	1. Structure: Mute Entire Site	2. Sill: Fill Entire Site Over Long-Term	3. Internal Diking

Subalternatives	1A. 6th Finger as-is	2A. Fill 6th Finger	3A. 6th Finger – No Fill
	1B. Fill 5 Fingers	2B. Fill 5 Fingers	3B. 5 Fingers
	1C. Fill South Marsh	2C. Fill South Marsh	3C. Fill South Marsh (not muted)
	1D. Fill Rookery	2D. Fill Rookery	3D. Fill Rookery
	1E. Fill all other areas	2E. Fill all other areas	3E. All subareas filled
Muting Options			1. Extreme
			2. Significant
			3. Moderate
			4. Symmetrical
			5. No Muting

3.3.1. No Project: No Change to Existing Conditions

The No Project Alternative assumes that existing conditions remain unchanged. The hydraulic connection to the larger Elkhorn Slough, the main channel, is not modified and slough elevations do not change. Tidal elevations in the Parsons Complex are roughly equal to those at Elkhorn Slough, which are similar to those of the open ocean. The site is left to evolve into whatever habitats would persist under future hydrologic and biogeochemical conditions. It is presently largely a mudflat with a relatively small subtidal area and a very small area of vegetated intertidal habitat. Sea level is free to rise, while marsh elevations either remain static and mudflats are unlikely to keep pace with sea level rise. Figure 3-1 shows existing elevations and corresponding habitats for the No Project Alternative relative to low water defined as North American Vertical Datum (NAVD), and Figure 3-2 shows an aerial photograph of the site condition.

3.3.2. Restoration Alternative 1: Water Control Structure at the Union Pacific Railroad (UPRR) Bridge

Restoration Alternative 1 includes the major restoration element of a water control structure across the main entrance channel (at the UPRR bridge) to mute the high tide but not the low tide. Tidal muting is desired to lower high water levels in the Complex sufficiently to provide for hydrologic conditions (inundation frequencies) suitable for establishment of vegetated salt marsh. Alternative 1 is designed to mute tides to a maximum target elevation of +2.5 feet (0.76

m) NAVD on the average high tides, while allowing water levels to drop to existing extreme low tides of approximately -1.5 feet (0.45 m) NAVD. The highest spring tide water levels would be allowed to enter unrestricted to fill the Parsons Complex by opening all culvert doors and allowing free flow-through of flooding tides. Figure 3-3 shows Alternative 1 including the location of the structure and areas of possible sediment additions, and Figure 3-4 shows a plan view of the structure. The UPRR would have to give permission to install the structure as it will be connected to their railroad levee.

The structure could be constructed of either stone as a very large levee, or as a concrete sheetpile wall, and be imbedded deeply enough below the channel bed to remain stable and prevent undermining. The crest would be at an elevation of +9 feet NAVD to fully block maximum spring tides from overtopping the structure, and to provide sufficient freeboard to account for sea level rise through the near future (20 years after construction). For these analyses, a stone/earthen levee is assumed to be the proposed concept because it is less expensive to build than a concrete wall, would function as well as the wall concept, and would potentially be more easily removed if necessary.

Multiple rows of culverts, some with tide gates, would be installed at various elevations to control high water levels. Figure 3-5 shows the concept design elevation of the structure and Figure 3-6 shows the concept cross-section. The view in Figure 3-5 is looking toward Elkhorn Slough from Parsons, under the bridge to attempt to provide the scale of the structure relative to the existing UPRR bridge. A conceptual arrangement of culverts was identified to achieve the desired tide control. This concept includes a total of thirteen culverts, arranged in two rows, which is required to achieve the target tidal elevations under existing sea level conditions. The culvert series would consist of:

- A top row of four culverts with no flap gates to allow free inflow and outflow of tides; the pipes are 2 feet (0.6 m) high and 4 feet (1.2 m) wide, and set at invert elevations of 0 feet NAVD; and

- A lower row of nine culverts with flap gates to allow only outflow of tides (complete tidal drainage); the combination of pipe sizes are seven that are 6 feet (1.82 m) high and 10 feet (3.04 m) wide with an invert elevation of -10 feet (-3.04 m) NAVD, and two that are 3 feet (0.91 m) high and 10 feet (3.04 m) wide with an invert elevation of -5 feet (-1.52 m) NAVD.

This type of culvert-dependant structure may be able to be modified at a later date if this alternative is selected. Additional culverts (with caps to keep them temporarily closed) could be installed at higher elevations to allow for adaptations to rising sea level over time. However, this option is limited by space available to place additional culverts through the structure because most of the cross-section is already occupied. Alternatively, the size of the culvert openings can be reduced by being closed or partially blocked using sluice gates or flash boards (manually placed or adjusted), thereby reducing tidal inflow. The effect of this management would be to keep high tide elevations the same as for post-restoration during future sea level rise.

The structure could be operated such that during maximum spring high tides all the culvert flap gates (or doors) were open to allow Parsons to fill to the same water surface elevation as Elkhorn, thereby equilibrating water levels on both sides of the UPRR levee to maintain the levee's integrity, as required by the UPRR. The culvert doors could either be opened manually or automatically. Both systems of management pose the disadvantage of potential failure of the operation and associated consequences to the levee. A fail-safe system may not yet exist to ensure that the culverts would always operate properly during the specific high tide conditions that pose a concern to the UPRR.

Tidal muting alone might result in significant conversion of the area to vegetated salt marsh. However, if larger areas of vegetated salt marsh are desired, the lowest-lying areas of the Parsons Complex could be filled and raised in elevation to also become vegetated salt marsh. The following subalternatives that involve filling subareas within the Parsons Complex have been identified for Alternative 1:

- 1A: No action is proposed at the 6th Finger as its existing elevation is suitable under Alternative 1 to create salt marsh habitat.
- 1B: Dike and fill the Five Fingers up to +2.25 feet (+0.68 m) NAVD (185,500 cubic yards).
- 1C: Dike and fill the South Marsh areas within restoration cells up to +2.25 feet (+0.68 m) NAVD (47,500 cubic yards).
- 1D: Dike and fill Rookery Lagoon up to +2.25 feet (+0.68 m) NAVD (56,500 cubic yards).
- 1E: Fill all other areas up to +2.25 (+0.68 m) NAVD (290,500 cubic yards).

Sediment additions at these areas would be done behind containment dikes. It is assumed for this analysis that no tidal muting occurs as a result of adding containment dikes. Figure 3-7 shows a concept sediment containment dike that could serve as a model for areas to receive fill. Due to the high sensitivity of Rookery Lagoon for shark breeding, this site was initially not included as a subalternative. However, after reconsideration it is now included here to offer the broadest range of options. ESNERR staff and researchers have recommended that this site be kept in the mix of options, but have cautioned that infilling of this area must be done as sensitively as possible to preserve valuable habitat to the greatest extent while creating new vegetated marsh habitat.

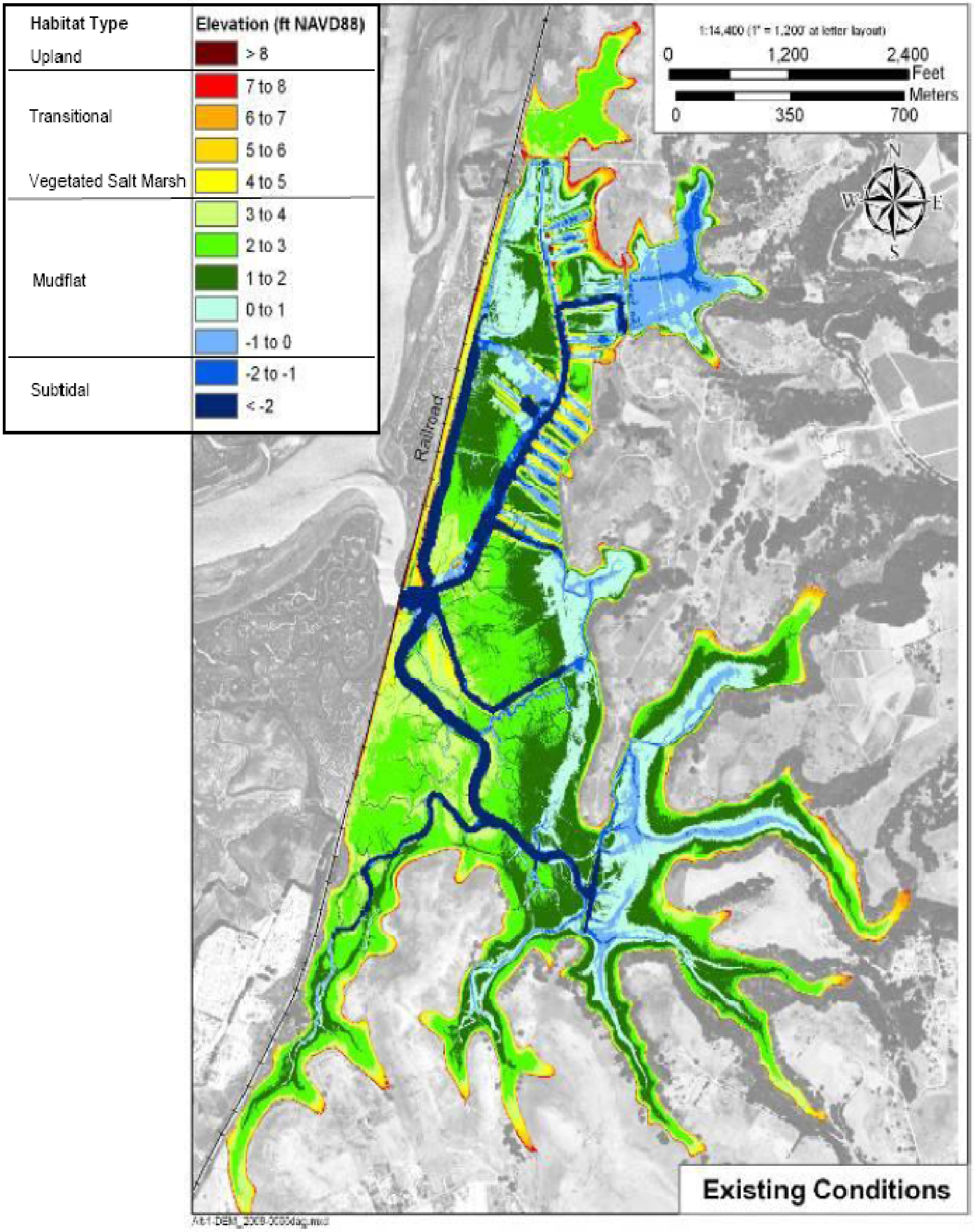


Figure 3-1 – Existing Conditions of Topography and Habitat

Figure 3-2 – Aerial Photograph of Existing Conditions for the No Project Alternative

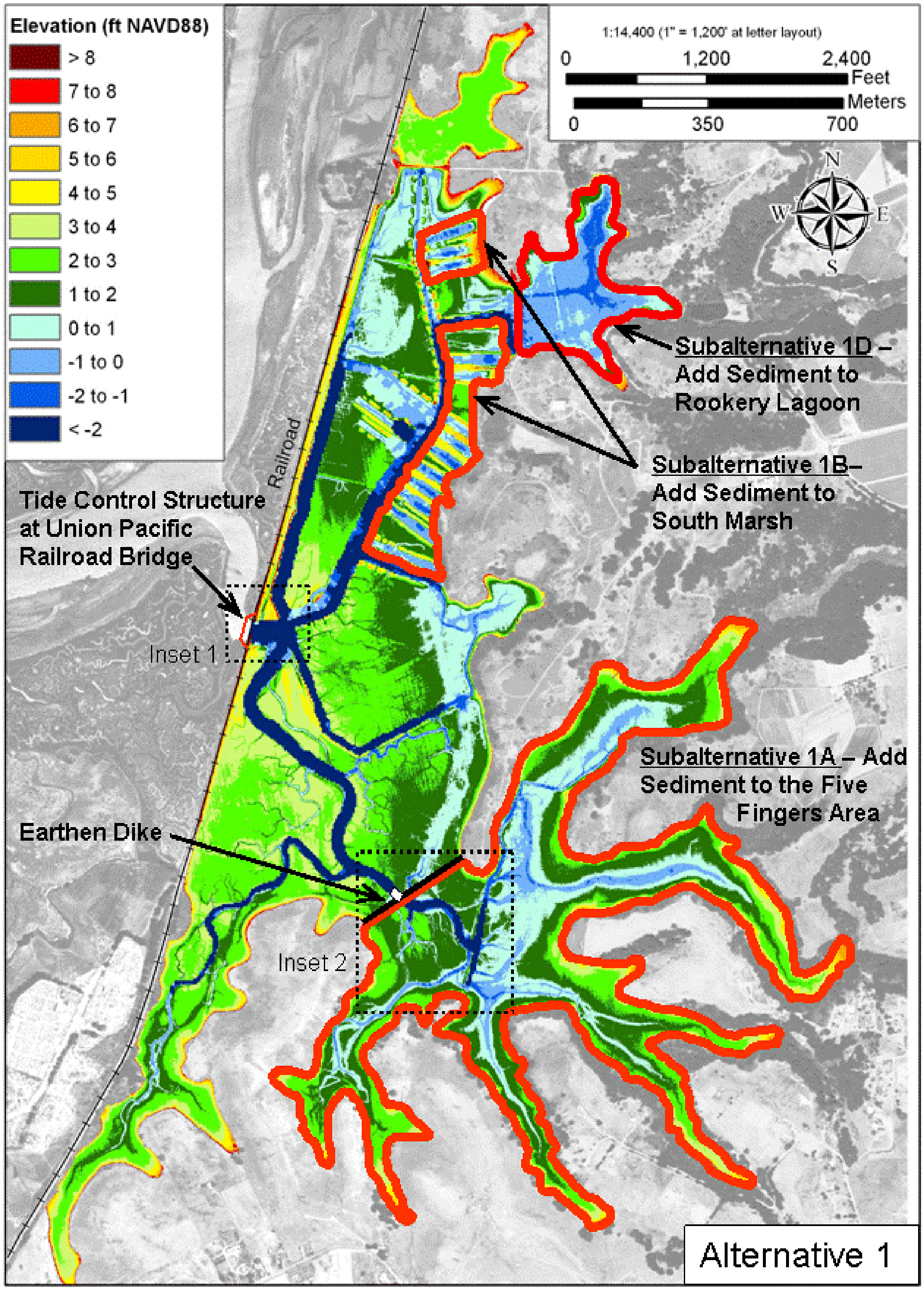


Figure 3-3 – Alternative 1 Concept

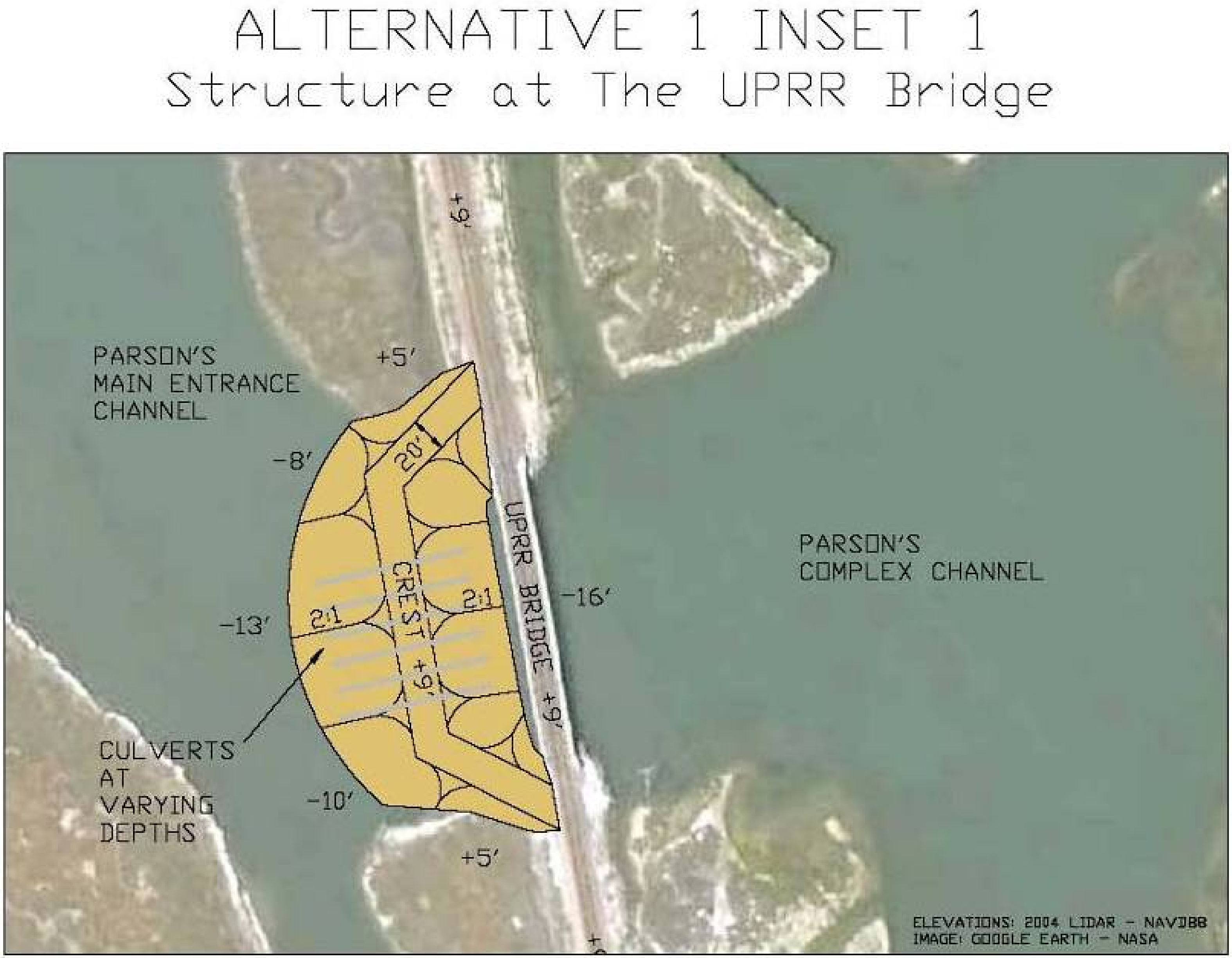


Figure 3-4 – Concept Plan of the Structure (Inset 1)

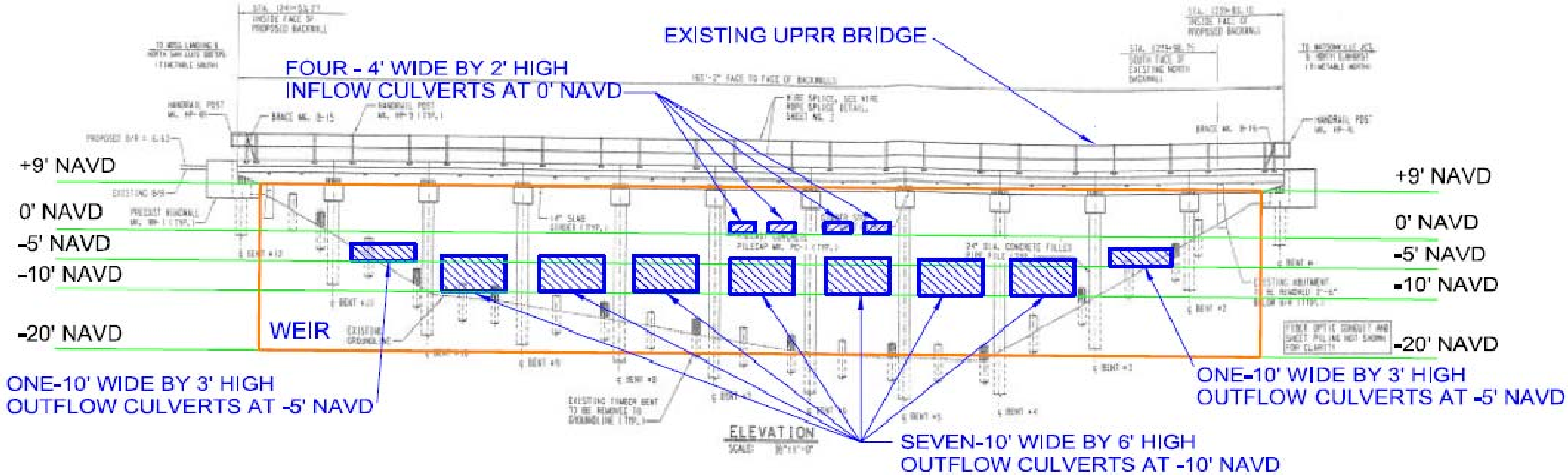


Figure 3-5 – Preliminary Design of the Structure

Note: This concept is shown with the UPRR Bridge in the foreground as the view looking north to depict the scale of it relative to the existing structure. The structure is in the background and culverts extend toward the UPRR Bridge.

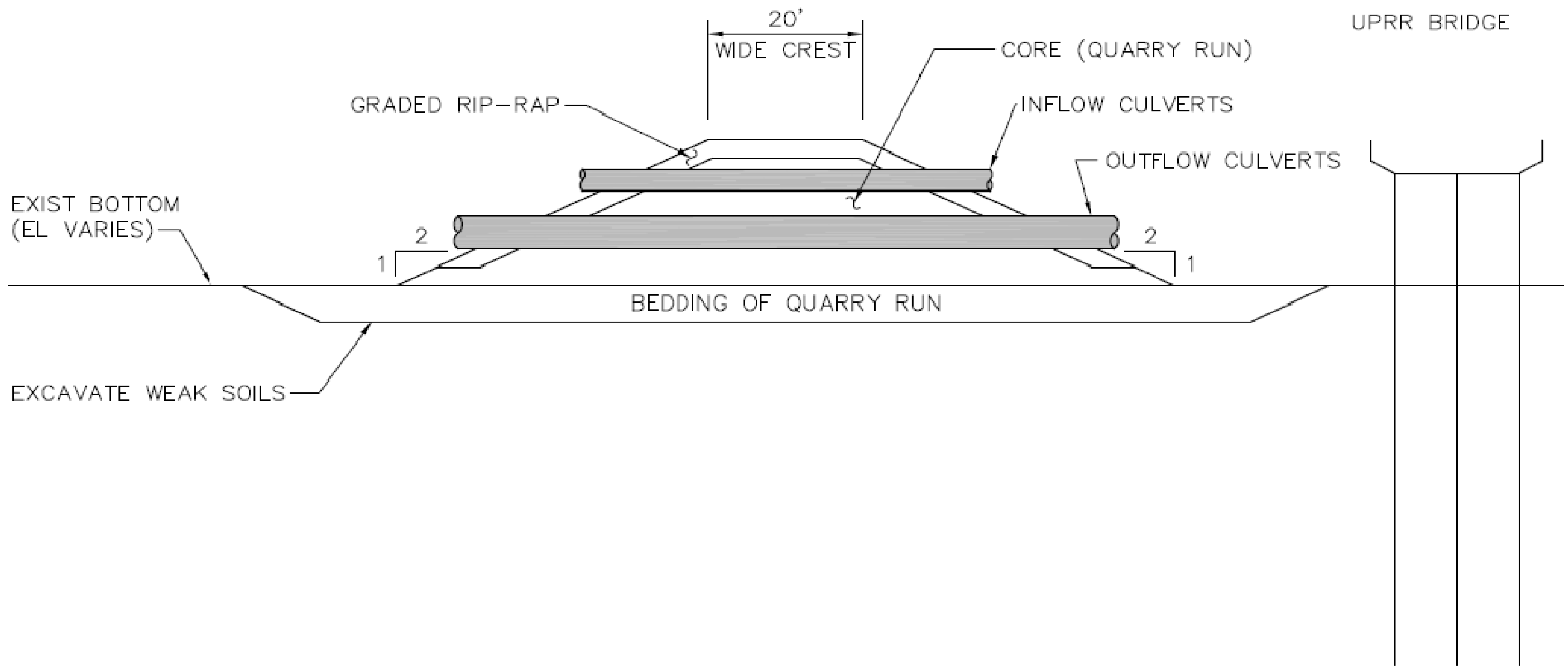


Figure 3-6– Typical Section of the Structure

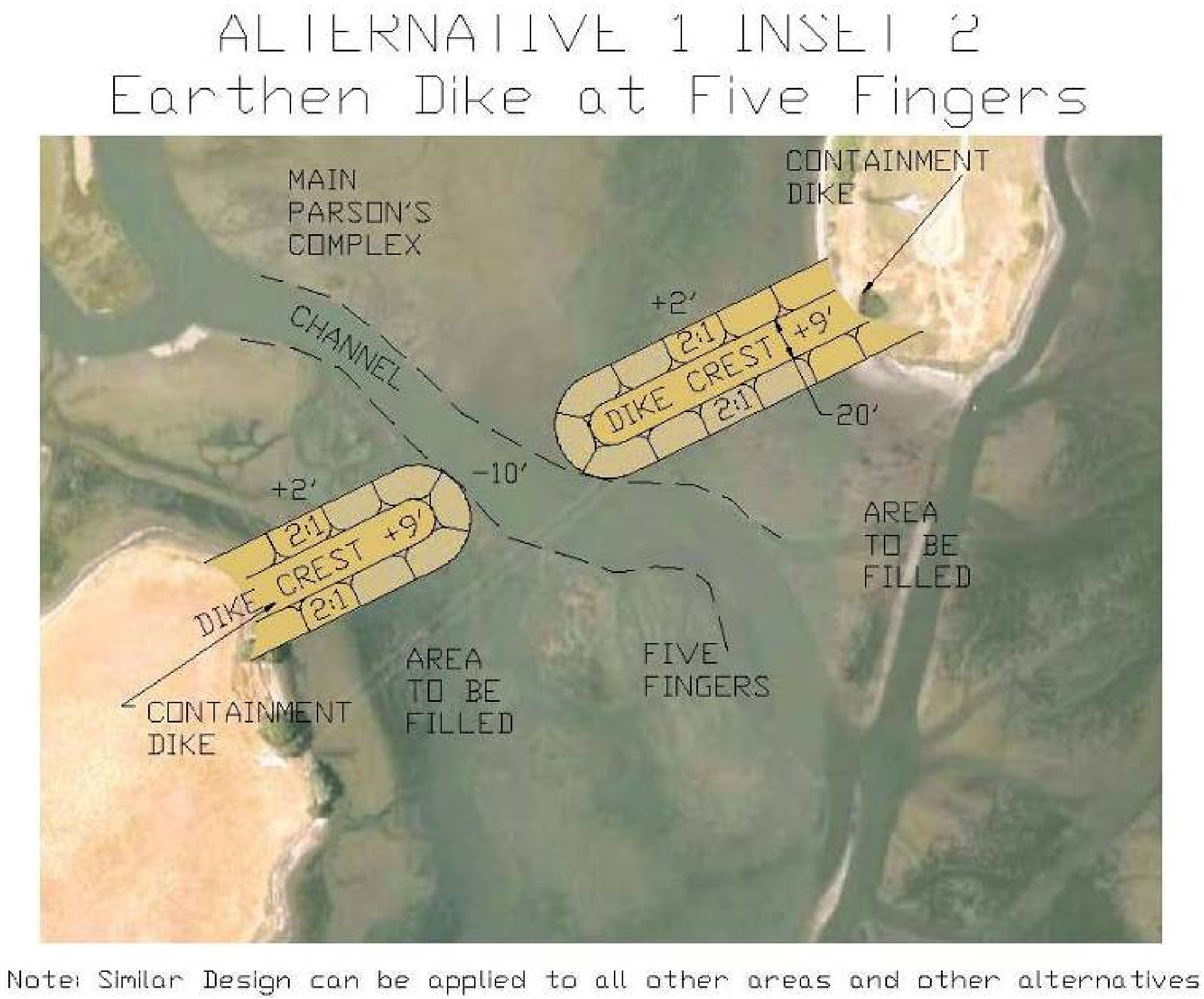


Figure 3-7– Concept Design of Containment Dikes (Inset 2)

3.3.3. Restoration Alternative 2: Sill Downstream of UPRR Bridge and Add Sediment

Alternative 2 consists of the major restoration element of a sill (a subtidal ridge) in the main entrance channel to the Parsons Complex to arrest channel head-cutting and reduce sediment export from the Parsons Complex, and large-scale sediment additions to raise the site to the elevation suitable for vegetated salt marsh. Figure 3-8 shows Alternative 2. The sill would be composed of very large rock and be imbedded/founded deeply enough below the channel bed to remain stable and prevent undermining into the 50-year future, assuming the existing rate of undermining will continue.

The sill would reduce the size of the channel cross-section over its crest and constrict tidal flows thereby increasing flow velocities over the crest of sill (not at other areas away from the sill) until the tidal prism is reduced from sediment additions. Therefore, smaller rock would be placed as scour protection on the crest of the sill, along the channel banks adjacent to the sill, and on the channel bed just upstream and downstream of the structure as a scour apron. The sill could be raised over time to keep pace with sea level rise, and to enable the bed elevation of the complex to rise at the same rate as sea level; however, the bed elevation would only increase if there is a significant source of sediment. Figure 3-9 shows a plan view of the sill, and Figure 3-10 shows a typical section of the sill, with a large volume of fill within Parsons behind the sill representing the ultimate effect of large-scale sediment additions.

In addition to the sill, this alternative assumes large-scale sediment addition to the entire complex to raise elevations sufficiently to establish vegetated salt marsh. The following subalternatives that involve filling subareas within the Parsons Complex have been identified for Alternative 2:

- 2A: dike and fill the 6th Finger with 124,111 cy.
- 2B: dike and fill the entrance to the Five Fingers area with 714,500 cy.
- 2C: dike ends of restoration cells and fill in the South Marsh area with 142,300 cy.
- 2D: fill within Rookery Lagoon with 151,370 cy.
- 2E: fill the remaining areas of the Parsons Complex with 1,203,074 cy.

Depending on the availability of suitable material, sediment could be added to the entire complex at one time or to individual areas sequentially over a long period of time. The volume of sediment needed to raise the entire Complex to the elevation appropriate for establishment of vegetated salt marsh is approximately 2.3 million cubic yards. Obtaining very large quantities of fill for the entire Parsons Complex is a major undertaking, very costly, and would cause impacts to the environment. If only smaller fill volumes are added, incremental fills within smaller areas of the fingers and other areas could occur to create vegetated salt marsh habitat. Filling would have to occur behind containment dikes to retain it in place. As such, it may be necessary, in some instances, to utilize culverts through the containment dikes to convey tides. It may be possible to contain fills with only dikes and no culverts, depending on site hydraulics and properties of the fill (i.e. grain size). However, for conservative estimating and analysis purposes, this report generally assumes some culverts would be needed at containment dikes for sediment additions.

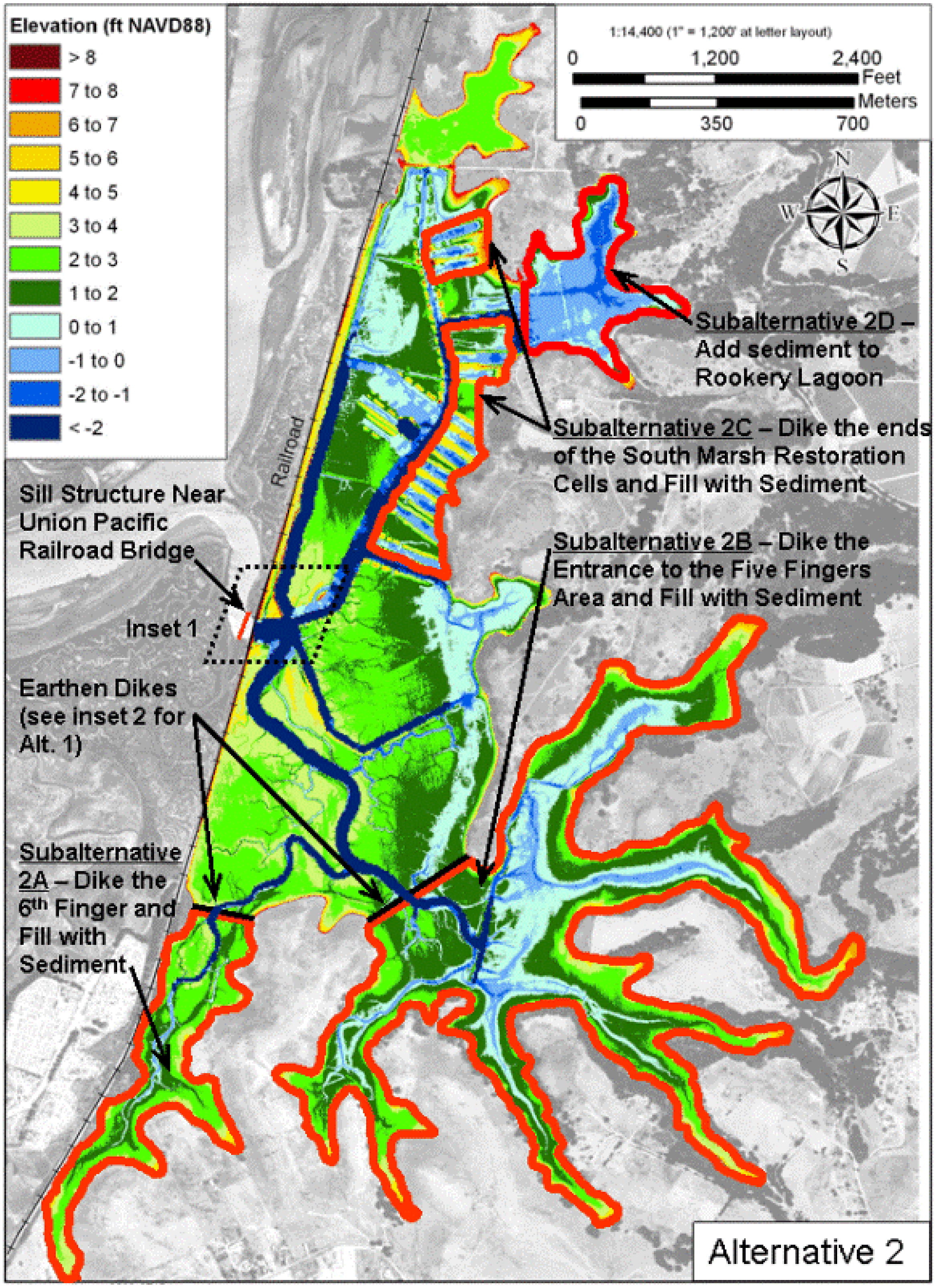


Figure 3-8– Alternative 2 Concept

ALTERNATIVE 2 - INSET 1
Sill Near UPRR Bridge

Figure 3-9– Concept Sill Plan

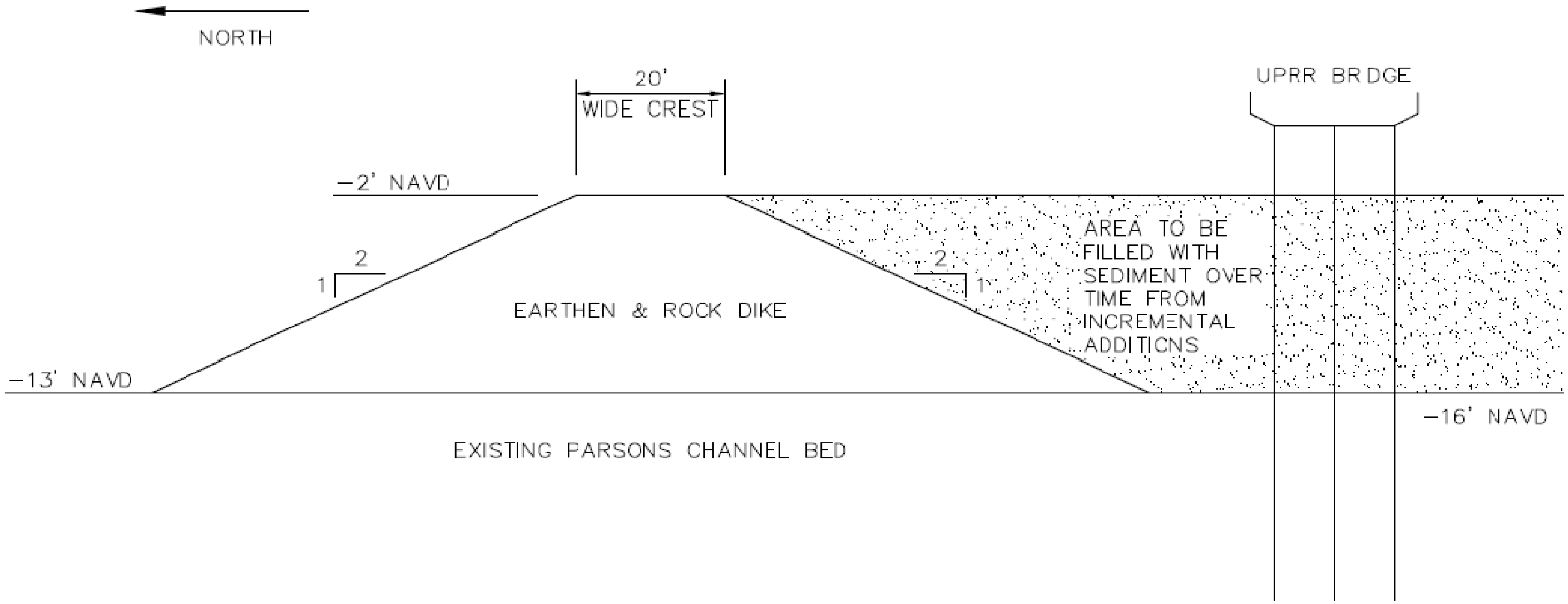


Figure 3-10- Typical Section of the Sill

3.3.4. Restoration Alternative 3: Internal Diking and Add Sediment

The major restoration elements of Alternative 3 include permanent internal diking, possible muting, and sediment addition at high priority areas, such as the 6th Finger, the Five Fingers area, South Marsh restoration cells, and Rookery Lagoon. Internal diking, possible muting, and sediment addition would avoid complications that could arise from opposition or lack of cooperation from the UPRR for actions at the railroad bridge. Although channel scour is less of an issue at the fingers, permanent internal dikes should be composed of rock and earthen fill, and be imbedded/founded deeply enough below the channel bed to remain stable and prevent erosion, breaching, and/or undermining throughout the 50-year future. Figure 3-11 shows Alternative 3. A preliminary concept design of the sediment containment dike erosion plan is shown in Figure 3-12.

Muting could occur at the site using culverts and flap gates to depress water levels and reduce the amount of fill needed to create habitat. Tidal muting could lower high tide elevations to create hydrologic conditions suitable for the formation of vegetated marsh habitat. Several muting options are envisioned under Alternative 3. The muting options are listed below.

- Muting Option 1, Extreme high tide muting - targeted as a maximum spring tide range from +1 foot to -0.4 feet (+0.30 to -0.12 m) NAVD requiring no sediment additions in order to support vegetated salt marsh. This option does not apply to the 6th Finger because the site is too high in elevation to make it a viable option.

- Muting Option 2, Significant high tide muting – targeted as a maximum spring tide range from +2 feet to -0.4 feet (+0.60 to -0.12 m) NAVD requiring very limited sediment additions in order to support vegetated salt marsh. No sediment would need to be added to the 6th Finger because it is high enough to transition to vegetated marsh with only muting.

- Muting Option 3, Moderate high tide muting - targeted as a maximum spring tide range from +4 feet to -0.4 feet (+1.2 to -0.12 m) NAVD requiring more extensive sediment additions to support vegetated salt marsh.

- Muting Option 4, Symmetrical muting of both the high and low tides – targeted as a maximum spring tide range from +4 feet to +2 feet NAVD (+1.2 to 0.60 m), requiring significant sediment additions to support vegetated salt marsh. Symmetrical muting provides the benefit of not having to use flap gates to control tidal elevations, but only pipe sizes to mute the tide range.

- No Muting Option 5, Add sediment behind containment dikes with no muting.

Figure 3-13 shows conceptual tidal muting options and fill elevations. Various combinations and arrangements of culverts are needed to control tides to the proposed levels. For example, muting tidal elevations at +2 feet to -0.4 feet NAVD (+0.6 to -0.12 m) at the 6th Finger would consist of three inflow-only pipes (with flap-gates on the inboard ends to prevent ebbing, if necessary) with inverts set at +3 feet (+0.9 m) NAVD, and five 3-foot (0.9 m) diameter outflow-only pipes (with flap-gates on the outboard ends to prevent flooding) with inverts set at -3 feet (-0.80 m) NAVD. More culverts and flap gates would be needed at the Five Fingers because the tidal prism at that area is larger than that of the 6th Finger. Figure 3-14 shows the conceptual dike and culvert cross-section.

Multiple culverts and tide gates could be installed at various elevations to enable adaptive management by closing initial inflow culverts and opening higher ones, depending on the performance of the structure and condition of rising sea level over time. Also, the dikes could be raised to keep pace with sea level rise thereby allowing the wetland bed elevation behind the dikes to rise at the same rate as sea level if fill were added. Alternatively, the sizes of the culvert openings can be reduced by being closed or partially blocked using sluice gates or flash boards (manually placed or adjusted), thereby reducing tidal inflow. The effect of this management would be to keep high tide elevations the same as for the immediate post-restoration period during future sea level rise.

There are many possible variations for muting and/or filling subareas of the Parsons Complex. The subalternatives are listed below as A, B, C, D, and E with tidal muting options included in parentheses as 1, 2, 3, and 4. Option 5 indicates no muting.

- 3A: Dike and mute the 6th Finger:
    - 3A(2) – Significant muting and no fill (site is elevated to +1.50 feet [+0.46 m], 5,500 cy of fill).
    - 3A(3) – Moderate muting and fill (elevate to +3.50 feet [+1.06 m], 55,000 cy of fill).
    - 3A(4) – Symmetrical muting and fill (elevate to +4.00 feet [+1.20 m], 77,100 cy of fill).
    - 3A(5) – No muting and fill (elevate to +5.00 feet [+1.52 m], 124,000 cy of fill).

- 3B: Dike and mute the Five Fingers area:
    - 3B(1) – Extreme muting and fill (elevate to +0.50 feet [+0.15 m], 17,000 cy of fill).
    - 3B(2) – Significant muting and fill (elevate to +1.50 feet [+0.46 m], 87,200 cy of fill).

- 3B(3) – Moderate muting and fill (elevate to +3.50 feet [+1.06 m], 409,700 cy of fill).
- 3B(4) – Symmetrical muting and fill (elevate to +4.00 feet [+1.20 m], 509,800 cy of fill).
- 3B(5) – No muting and fill (elevate to +5.00 feet [+1.52 m], 717,000 cy of fill).

- 3C: Dike and fill the restoration cells in the South Marsh area:
  - 3C – No muting (due to the extensive number of cells and consequent number of culverts and flap gates required), but fill (elevate to +5 feet [+1.50 m], 142,300 cy of fill)

- 3D: Fill Rookery Lagoon as subalternative 3D:
  - 3D(1) – Extreme muting and no fill (elevate to +0.50 feet [+0.15 m], 16,800 cy of fill)
  - 3D(2) – Significant muting and fill (elevate to +1.50 feet [+0.46 m], 36,800 cy of fill)
  - 3D(3) – Moderate muting and fill (elevate to +3.50 feet [+1.06 m], 96,000 cy of fill)
  - 3D(4) – Symmetrical muting and fill (elevate to +4.00 feet [+1.20 m], 113,400 cy of fill)
  - 3D(5) – No muting and fill (elevate to +5.00 feet [+1.52 m], 151,000 cy of fill).

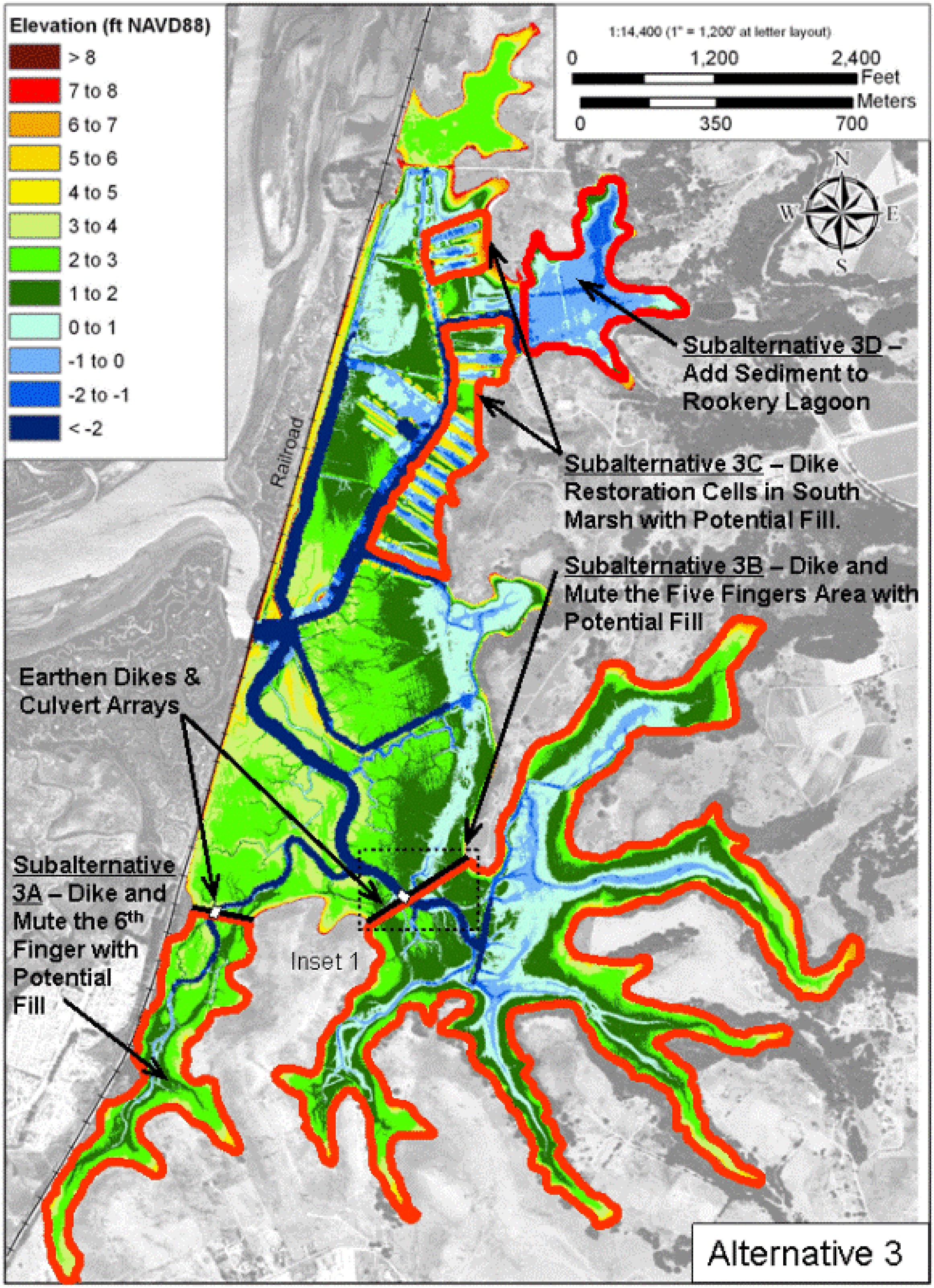


Figure 3-11– Alternative 3 Concept

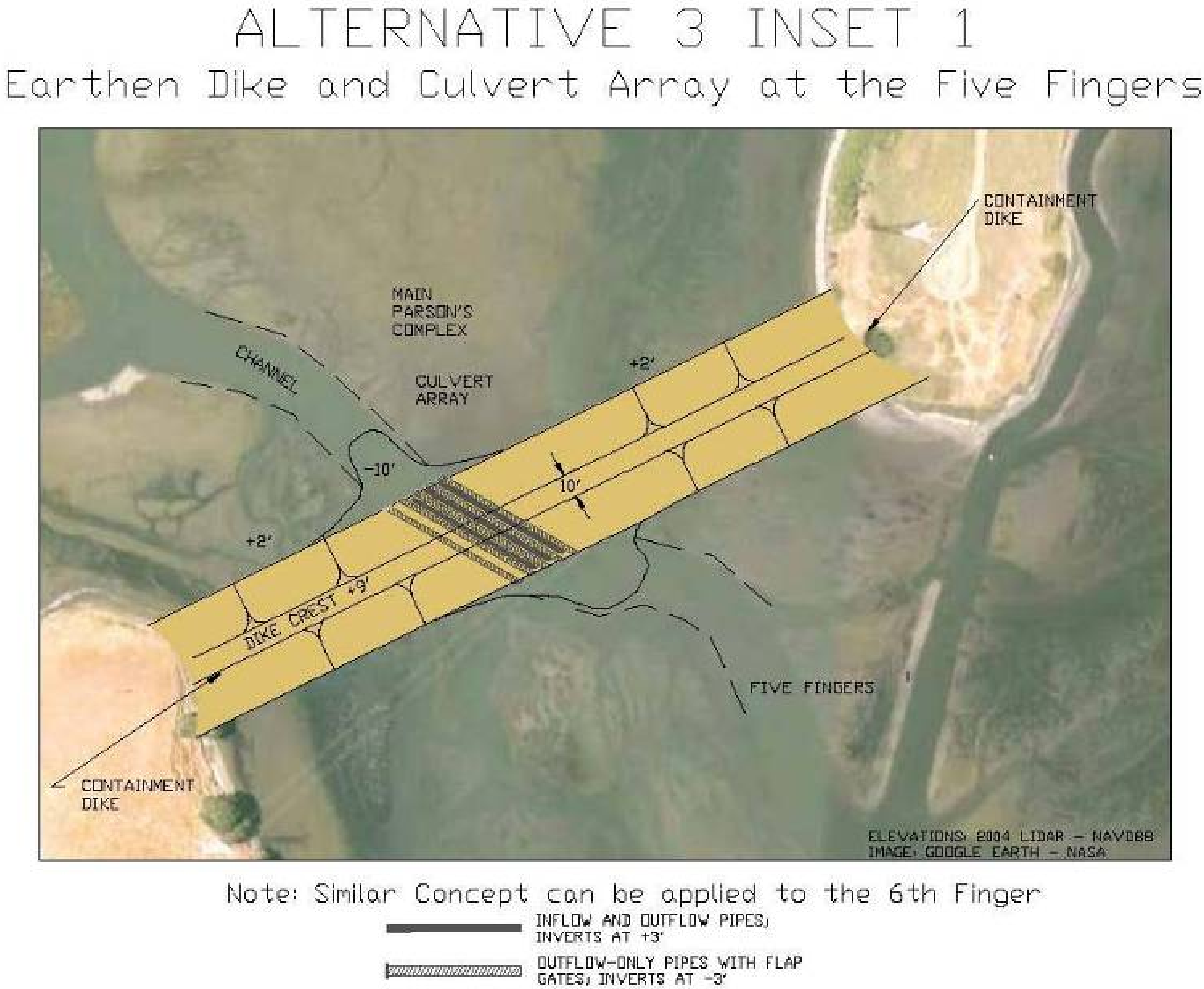


Figure 3-12– Concept Internal Containment Dike Plan

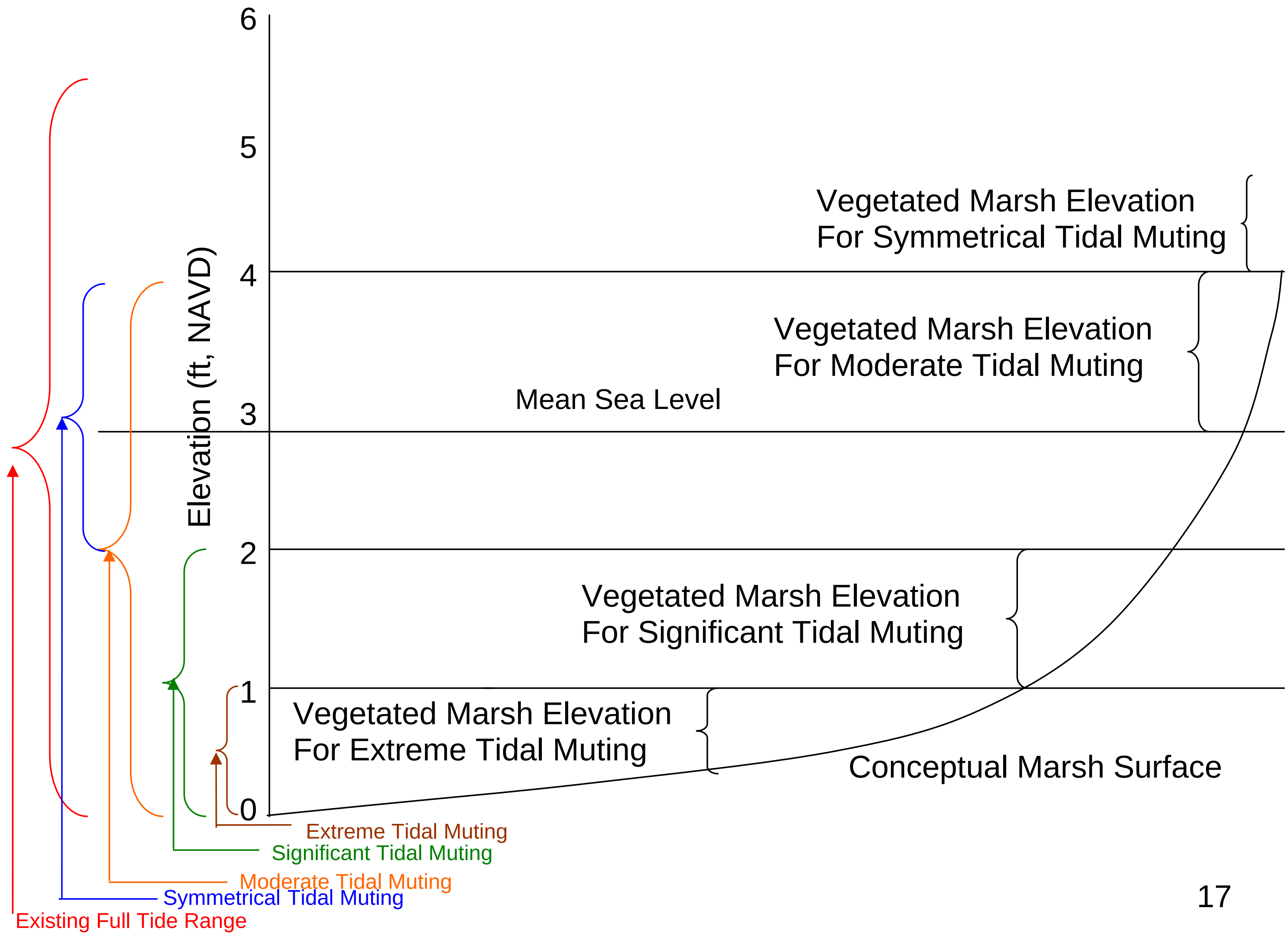


Figure 3-13 – Conceptual Tidal Muting Options

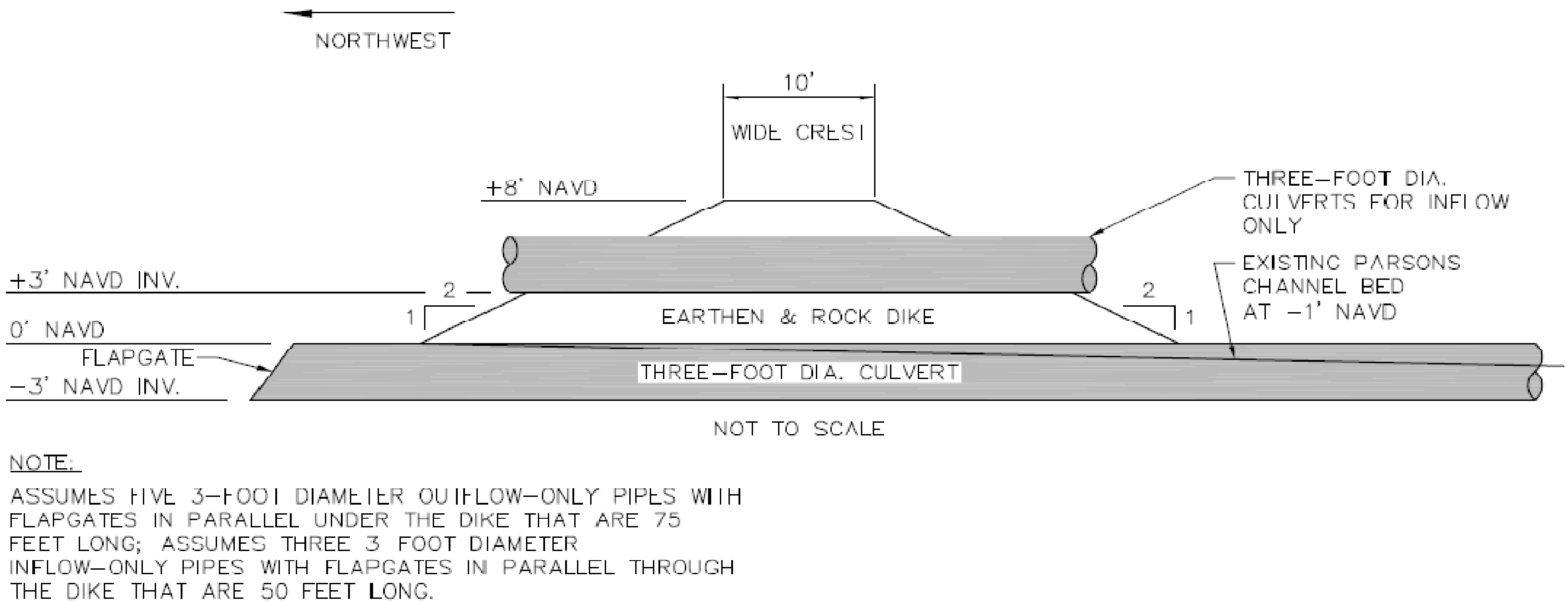


Figure 3-14 – Internal Containment Dike Section for Extreme Tidal Muting

3.4. Analysis of Restoration Alternatives

Restoration alternatives are evaluated to provide useful information to determine a preferred alternative. Alternatives are assessed herein for the following parameters:

- Tidal Hydrology and Hydraulics.
- Water Quality.
- Sea Level Rise.
- Habitat Changes (Quantity and Quality).
- Potential Impacts to the Railroad Levee and Related Structures.
- Maintenance Requirements.
- Estimated Construction Costs.
- Preliminary Environmental Review.
- Compatibility with Future Sediment Additions and/or the Larger Elkhorn Slough Project.
- Consistency with Project Goals and Objectives.

Analyses of each parameter are presented below for the major alternatives, plus certain subalternatives. Due to the large number of subalternatives (a total of 12, with 4 different potential tidal muting scenarios) not all subalternatives are analyzed in each section, but representative conditions are analyzed for each major alternative to provide feasibility-level information for decision-making. Timeframes addressed in the analyses include periods immediately after construction, and at 5 and 20 years after implementation.

3.4.1. Tidal Hydrology and Hydraulics

Numerical modeling was utilized to assess tidal hydrologic and hydraulic conditions for the alternatives. Storm flow conditions are not as critical to habitat evolution over time at this site compared to tidal conditions due to the infrequency of storm flows and their relative short duration, and as such, they were not analyzed. The objectives of the modeling were to quantify future tidal elevations, tide ranges, tidal inundation frequencies, tidal prisms, and flow velocities. These parameters were used to identify future physical conditions for habitat evolution, and to quantify seawater residence times in the Complex to indicate relative water quality conditions.

Numerical hydrodynamic modeling was done for the four basic alternatives to quantify effects of major modifications to the hydrologic system. Modeling was done and hydrology/hydraulic data are reported for:

- No Project – Existing conditions.
- Alternative 1 – Structure only, with no subalternatives of fill to isolate effects of the structure.
- Alternative 2 – Sill, with no fill to isolate effects of the sill.
- Alternative 2 – Sill, with all areas filled (subalternatives 2A through 2E inclusive) to test effects of large-scale fill. Modeling for this alternative with no fill is equivalent to assessment of Alternative 3B(5).
- Alternative 3B (tidal muting options 1-4) – Internal Muting, with all muting options for the Five Fingers subarea used as a representative example to limit the number of model runs and iterations required to assess subalternatives to within scope. The no muting option (5) would result in tidal elevations that are the same as existing conditions and Alternative 2.

The model being used for these tests was developed by Phillip Williams & Associates (PWA) for the Elkhorn Slough Project. It was calibrated, verified, and used in previous studies (PWA, 2007). For the purposes of this study, data from the December 2005 verification period presented in the 2007 PWA study were used, as that period includes a full spring-neap cycle and is the longest period available for simulation. The PWA model setup was not modified other than to incorporate the proposed alternatives. A full description of that modeling effort and results is presented in the Hydrodynamic Calibration Report for Elkhorn Slough (PWA, 2007).

The model Delft3D is the hydrodynamic modeling platform used in the simulation of Elkhorn Slough and in the testing of the proposed modifications to the Parsons Complex. All alternatives involve the simulation of flow through culverts so it is necessary to describe the formulation of culverts within Delft3D.

For each culvert, a number of attributes must be specified. These attributes include the height and width of the culvert, the elevation of the base (invert) of the culvert, the culvert length, and several parameters related to friction and energy losses. These loss parameters are Manning's number, n, the Correction Coefficient, α, and the Loss Coefficient C_d. These coefficients can be derived from standard culvert flow equations. In all tests, the following values for these parameters are cited from the Federal Highway Administration (2001):

n = 0.014 (Manning's roughness coefficient for concrete culverts)

α = 0.5 (Culvert entrance loss coefficient)

C_d = 1.0 (Culvert exit loss coefficient)

In simulating flow through a culvert, Delft3D is able to simulate the five different types of flow through the culvert that are generally considered and defined in the literature, including conditions such as: 1) supercritical flow, 2) tranquil flow, 3) submerged flow, 4) rapid flow at the inlet, and 5) free flow at the outlet. The type of flow simulated is chosen by Delft3D based on local hydraulic conditions at each time step.

The model was set up to provide tidal flow to and from the Parsons Complex from Elkhorn Slough. Tide data from Elkhorn Slough provided by PWA as results of their modeling study were used to drive tides in the Parsons Complex. Model results are presented below for hydrology/hydraulics, and inundation frequency, tidal prism, flow velocity, and water quality.

3.4.1.1. Tidal Ranges, Elevations and Lag Times

The model specifies tidal ranges, elevations and lag times through the Parsons Complex over time in response to tidal forcing conditions in Elkhorn Slough. Tidal elevations are specified below for the alternatives and shown in Table 3-2.

3.4.1.1.1. No Project

Existing conditions of the No Project Alternative at Parsons Complex would be nearly identical to those in the adjacent area of Elkhorn Slough. The maximum spring tidal range would be 8.42 feet (2.57 m) which would be the same as in Elkhorn Slough. Maximum spring tidal elevations could reach + 6.89 feet to -1.5 feet (+2.1 m to -0.46 m) above and below NAVD, respectively. The predicted lag time between minimum water surface elevations in the Parsons Complex compared to Elkhorn Slough would be 21 minutes and that time lag would occur in the most distant reaches of Parsons.

3.4.1.1.2. Alternative 1 – Structure Only

Alternative 1 is designed to mute tides to a maximum elevation of +2 feet (+0.6 m) NAVD on the highest spring tides, while allowing water levels to drop to existing lows at approximately -1.5 feet (- 0.46 m) NAVD. This water level control is intended to lower overall water levels to those required to provide suitable hydrologic conditions for establishment of vegetated salt marsh, considering existing marsh surface elevations.

The model predicts that a maximum spring tidal range of 4.0 feet (1.22 m), with a maximum spring high tidal elevation of + 2.5 feet and a minimum low spring tidal elevation of -1.5 feet (+0.76 m to -0.46 m). Figure 3-15 shows tidal elevation curves for Alternative 1 compared to existing conditions. The restriction of the incoming tide would change the tidal signal in the Parsons Complex from semi-diurnal to asymmetric diurnal. Under these modified conditions, the tidal signal would take longer to reach high tide than it would to reach low tide. Note that the number of outflow pipes could be reduced from the number of assumed for modeling as site drainage is not impeded.

Table 3-2 – Predicted Tidal Elevations of Alternatives

Alternative and Any Subalternatives	Tidal Range		Maximum Spring High Tide Elevation		Minimum Spring Low Tide Elevation		Mean Higher High Water Elevation		Mean Lower Low Water	
	Ft.	M	Ft.	M	Ft.	M	Ft.	M	Ft.	M
No Project	8.42	2.57	6.89	2.10	-1.5	-0.46	-0.23	0.7	5.75	1.75
1 – Structure Only	4.0	1.22	2.5	0.75	-1.5	-0.46	-0.74	-0.22	2.32	0.7
2 – Sill (With and Without Fill – same results)	8.42	2.57	6.89	2.10	-1.5	-0.46	-0.23	-0.7	5.75	1.75
Alternative 3, Subalternative B, Internal Muting at the Five Fingers	See Below		See Below		See Below		See Below		See Below	
3B(1) – Extreme Muting	1.65	0.50	1.25	0.38	-0.40	-0.12	-0.08	-0.02	0.76	0.23
3B(2) – Significant Muting	2.7	0.82	2.3	0.7	-0.4	-0.12	0.15	0.04	1.56	0.47
3B(3) – Moderate Muting	4.7	1.43	4.3	1.31	-0.4	-0.12	0.20	0.06	3.89	1.18
3B(4) – Symmetrical Muting	2.0	0.61	4.9	1.49	2.9	0.88	3.18	1.15	4.26	1.29

One fairly significant changed condition could result at the area just north of the 6th Finger from this alternative. The area just north of the 6th Finger is relatively high in elevation, at between +2 feet (+0.6 m) and +4 feet (+1.2 m) NAVD. Predicted high tides for Alternative 1 would reach maximum elevations of +2.5 feet (+0.76 m) potentially causing the area just north of the 6th Finger to either remain dry or receive only very small quantities of seawater with resultant shallow water depths. This area would likely evolve into vegetated salt marsh and transitional area. Whistlestop Lagoon appears to experience the same process, however the elevation data for that lagoon may not accurately represent the surface due to the aerial method of data collection (LIDAR) not being able to penetrate the water surface.

3.4.1.1.3. Alternative 2 – Sill With Fill (2A-2E) and Without Fill (2 Only)

Since Alternative 2 does not propose tidal muting at the UPRR bridge, tidal elevations at the main Parsons Complex would remain the same as existing conditions. The predicted maximum spring tidal range would be 8.42 feet (2.56 m), and spring tidal elevations would vary from + 6.89 feet at high tide to -1.50 feet at low tide (+2.07 to -0.46 m). The predicted lag time between low tidal elevations in Elkhorn and Parsons could be 21 minutes. Figure 3-16 shows tidal elevations for Alternative 2.

3.4.1.1.4. Alternative 3 - Subalternative B – Internal Dikes and Muting at the Five Fingers

Four different tidal muting scenarios were analyzed for Alternative 3, subalternative 3B - internal muting at the Five Fingers, in order to bracket a possible range of hydrologic and hydraulic options. The tidal muting scenarios were conceived to perform as specified below under the set of bullets labeled as design targets, and model predictions for these options are listed in the second set of bullets labeled as model predictions to compare how well the hydrologic tidal elevation target is achieved with the concept design. Tides for Alternative 3, subalternatives A-E(5) would be the same as for existing conditions.

<u>Design Targets</u>

Subalternative 3B(1)

- Target: Extreme muting of the high tide, designed as a 1 foot tide range from +1 foot to 0 feet (+0.30 to 0 m) NAVD representing no sediment additions.

- Model Result: Extreme muting of the high tide (1 foot tide range from +1 foot to 0 feet (+0.30 to 0 m) NAVD representing no sediment additions: The maximum spring tidal range predicted by the model would be 1.65 feet (0.50 m) and elevations would be from +1.25 feet to -0.40 feet (+0.38 to -0.12 m) NAVD. The predicted tidal fluctuation in the Parsons Complex would potentially change to a steadily rising water level during neap tide periods in Elkhorn Slough, resulting in minimal tidal exchange and longer tidal residence times. Figure 3-17 shows tides for tidal muting option 1.

Subalternative 3B(2)

- Target: Significant high tidal muting designed with a tide range from +2 feet to 0 feet (+0.60 to 0 m) NAVD representing very limited sediment additions.

- Result: Significant high tidal muting with a tide range from +2 feet to 0 feet (+0.60 to 0 m) NAVD representing very limited sediment additions: The maximum spring tidal range predicted by the model would be 2.70 feet (0.82 m) and elevations would be from +2.30 feet to -0.40 feet (+0.70 to -0.12 m) NAVD. Similar to subalternative 3B(1), the

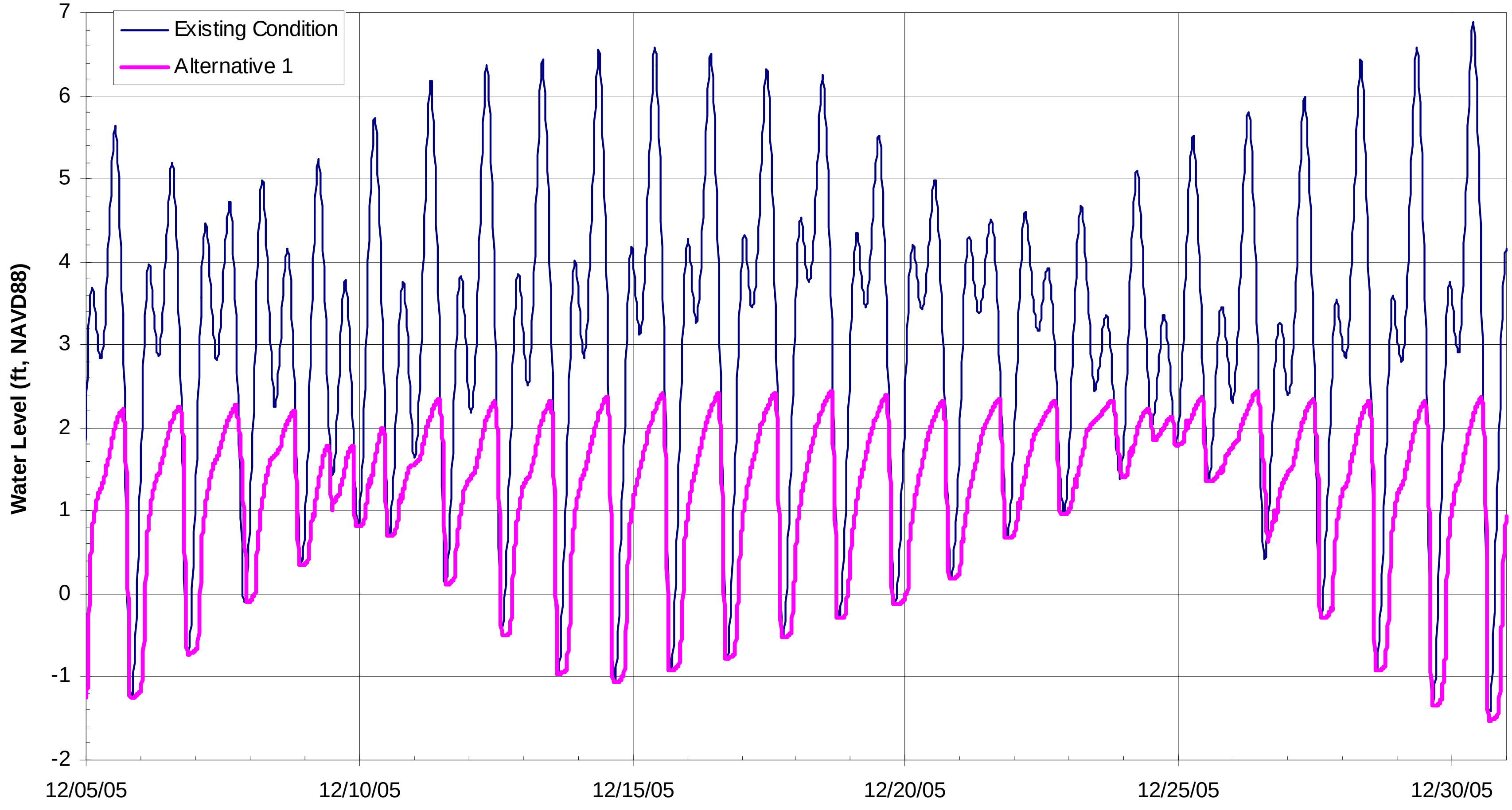


Figure 3-15- Tidal Elevation Curve for Alternative 1

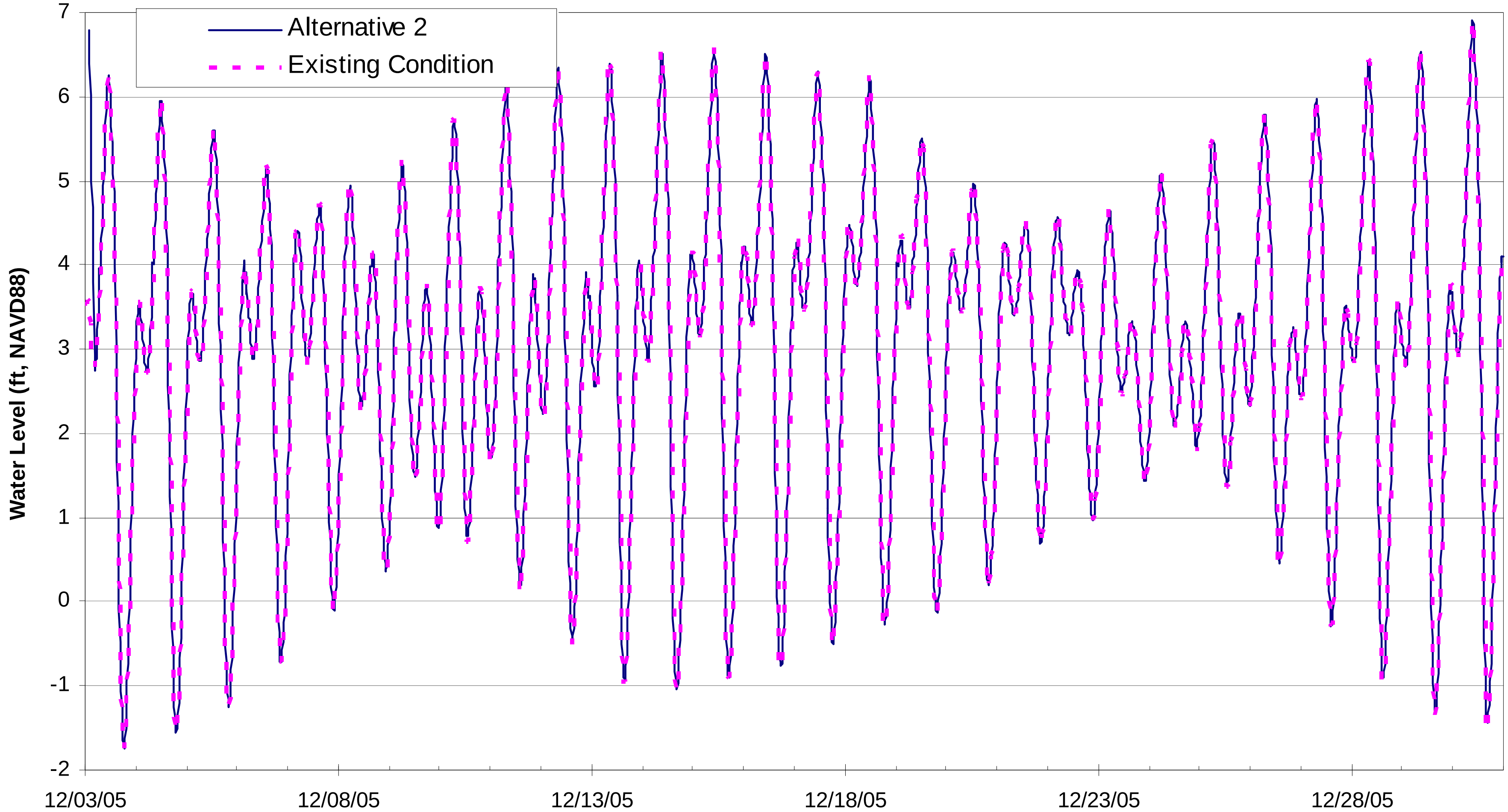


Figure 3-16 - Tidal Elevation Curve for Alternative 2

predicted tidal fluctuation in the Parsons Complex would potentially change to a steadily rising water level during the last half of neap tide period in Elkhorn Slough, resulting in minimal tidal exchange and longer tidal residence times. Figure 3-18 shows tides for tidal muting option 2.

Subalternative 3B(3)

- Target: Moderate high tide muting designed with a tide range from +4 feet to 0 feet (+1.20 to 0 m) NAVD representing more extensive sediment additions.

- Result: Moderate high tide muting with a tide range from +4 feet to 0 feet (+1.22 to 0 m) NAVD representing more extensive sediment additions: The maximum spring tidal range predicted by the model would be 4.70 feet (1.43 m) and elevations would be from +4.30 feet to -0.40 feet (+1.31 to -0.12 m) NAVD. Figure 3-19 shows tides for tidal muting option 3.

Subalternative 3B(4)

- Target: Designed for muting of both the high and low tides symmetrically about mean sea level with a tide range from +4 feet NAVD to +2 feet NAVD (+1.20 m to 0.60 m) representing both significant sediment additions and reduction of the tidal prism.

- Result: Muting of both the high and low tides symmetrically about mean sea level representing both significant sediment additions and reduction of the tidal prism: The maximum spring tidal range predicted by the model would be 1.20 feet (0.37 m) and elevations would be from +4.90 feet to +3.7 feet (+1.49 to +1.13 m) NAVD. Muting symmetrically about mean sea level was not accomplished by this culvert configuration as mean water levels in the marsh are elevated by approximately 0.60 feet (0.18 m) above the average water level of the driving tide in Elkhorn. This is due to impeded drainage of ebbing tides that could be solved by adding one or more outflow-only culverts (with flap gate control to prevent inflow). Figure 3-20 shows tides for tidal muting option 4.

Each muting scenario would be feasible to accomplish assuming various sizes, combinations, and arrangements of culverts. Modeling was done for the Five Fingers area under these options to show representative conditions.

Model predictions for all Alternative 3 scenarios show that the restriction of the incoming tide would change the tidal signal in the Parsons Complex from semi-diurnal to asymmetric diurnal. Under these modified conditions, the tidal signal would take longer to reach high tide than it does to reach low tide. The predicted lag time between low tides in Elkhorn Slough and the center of the Five Fingers for extreme muting scenarios would be 5.5 hours.

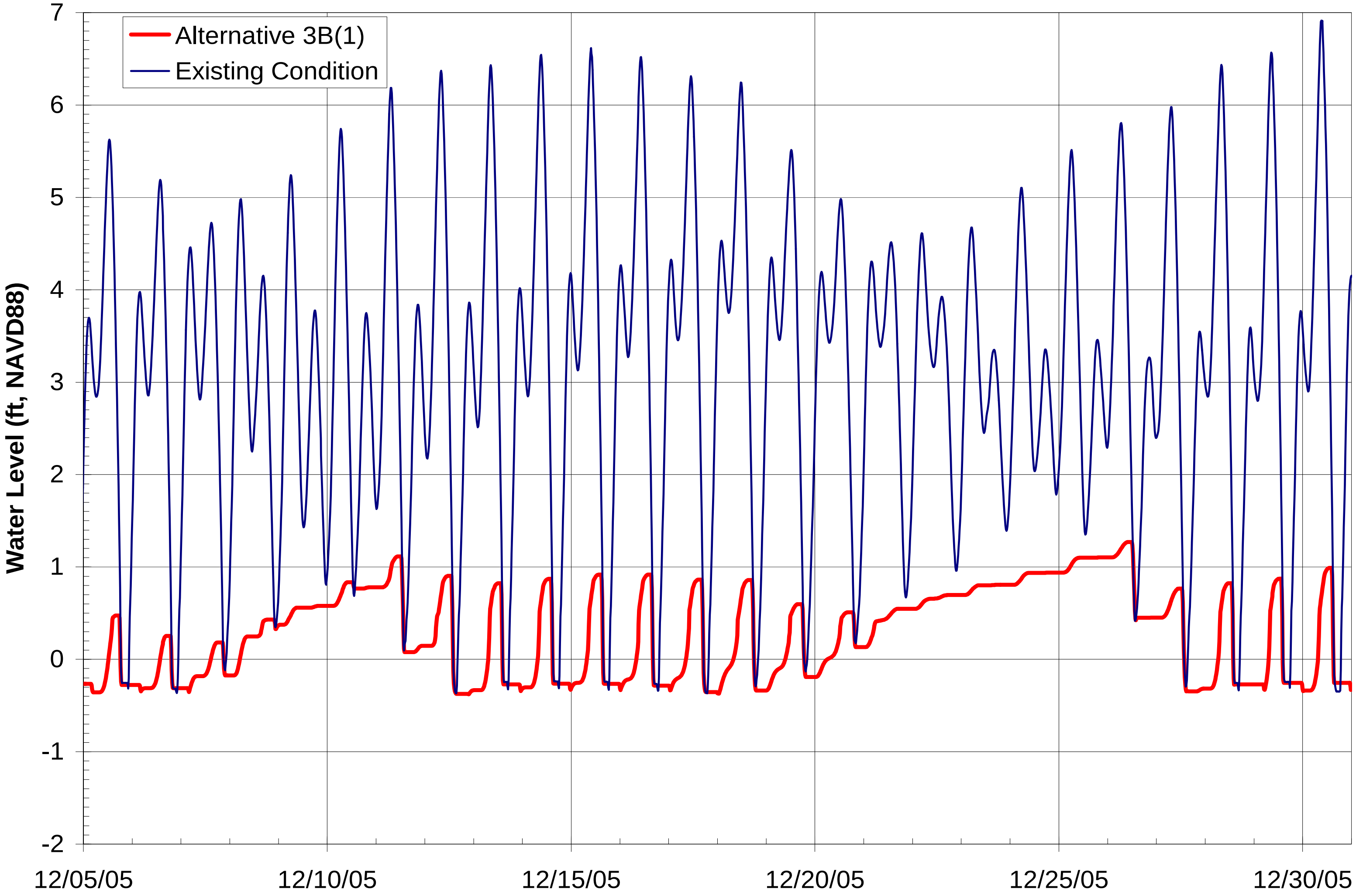


Figure 3-17 - Tidal Elevation Curve for Extreme Internal Muting Subalternative 3B(1)

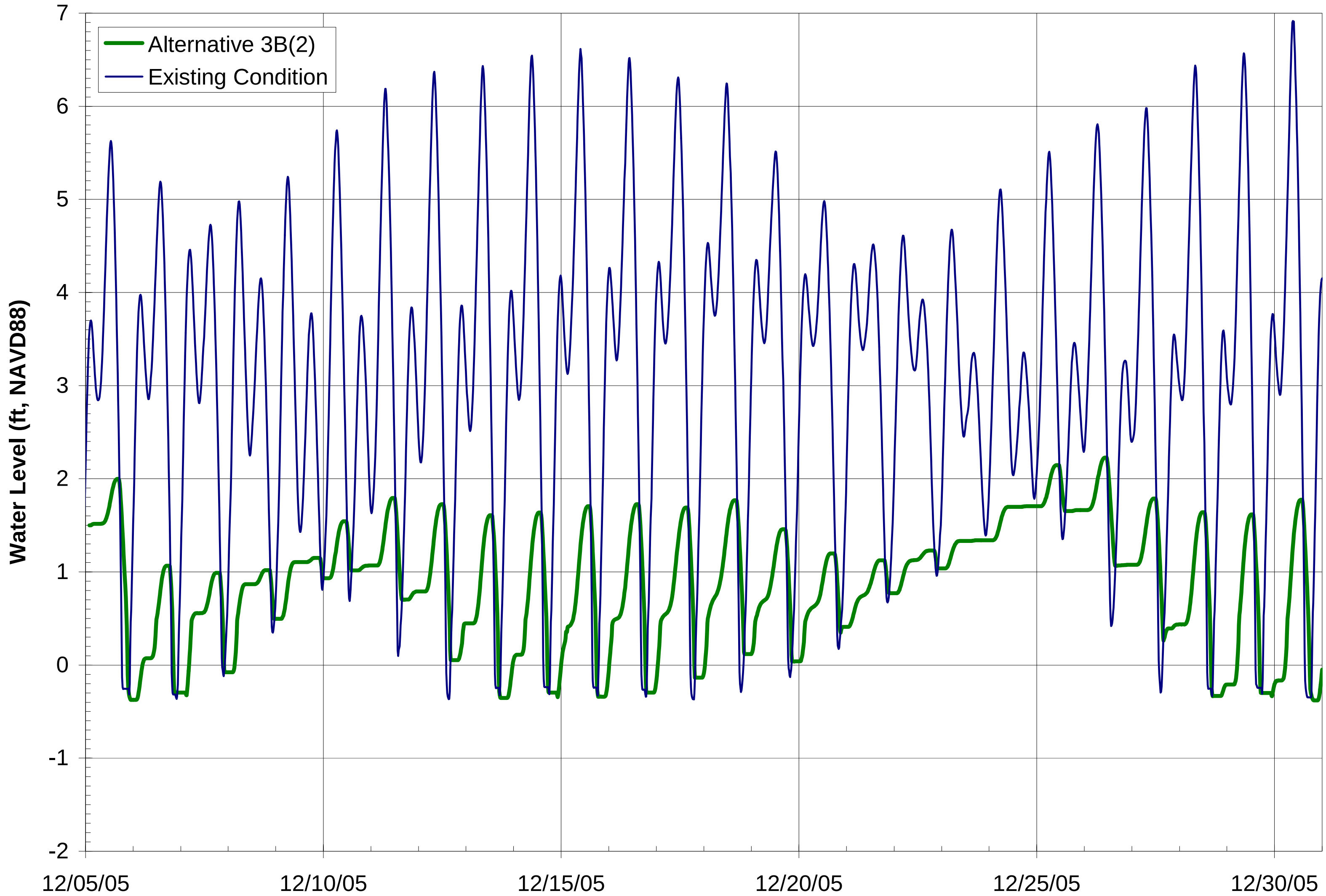


Figure 3-18 - Tidal Elevation Curve for Significant Internal Muting Subalternative 3B(2)

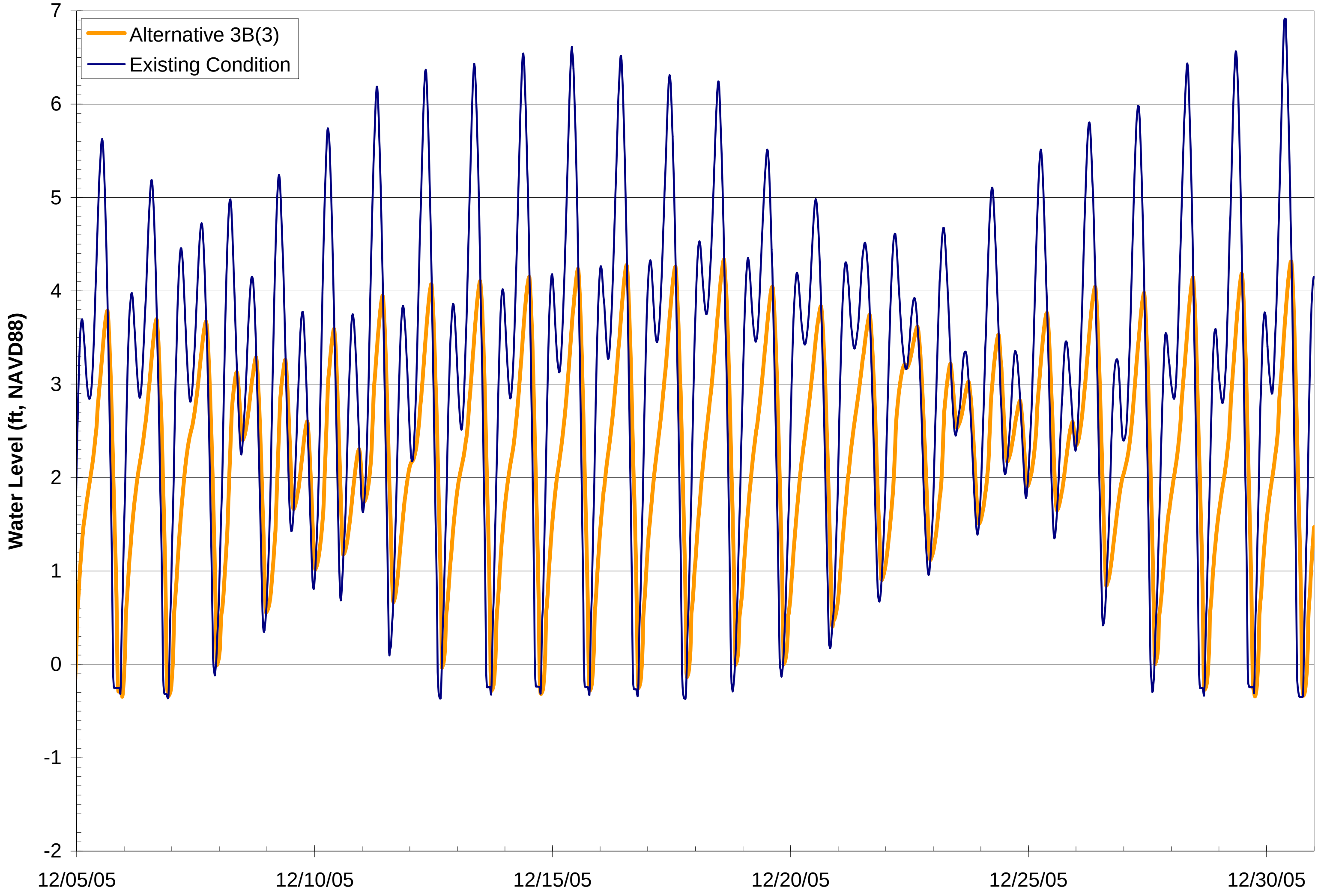


Figure 3-19 - Tidal Elevation Curve for Moderate Internal Muting Subalternative Alternative 3B(3)

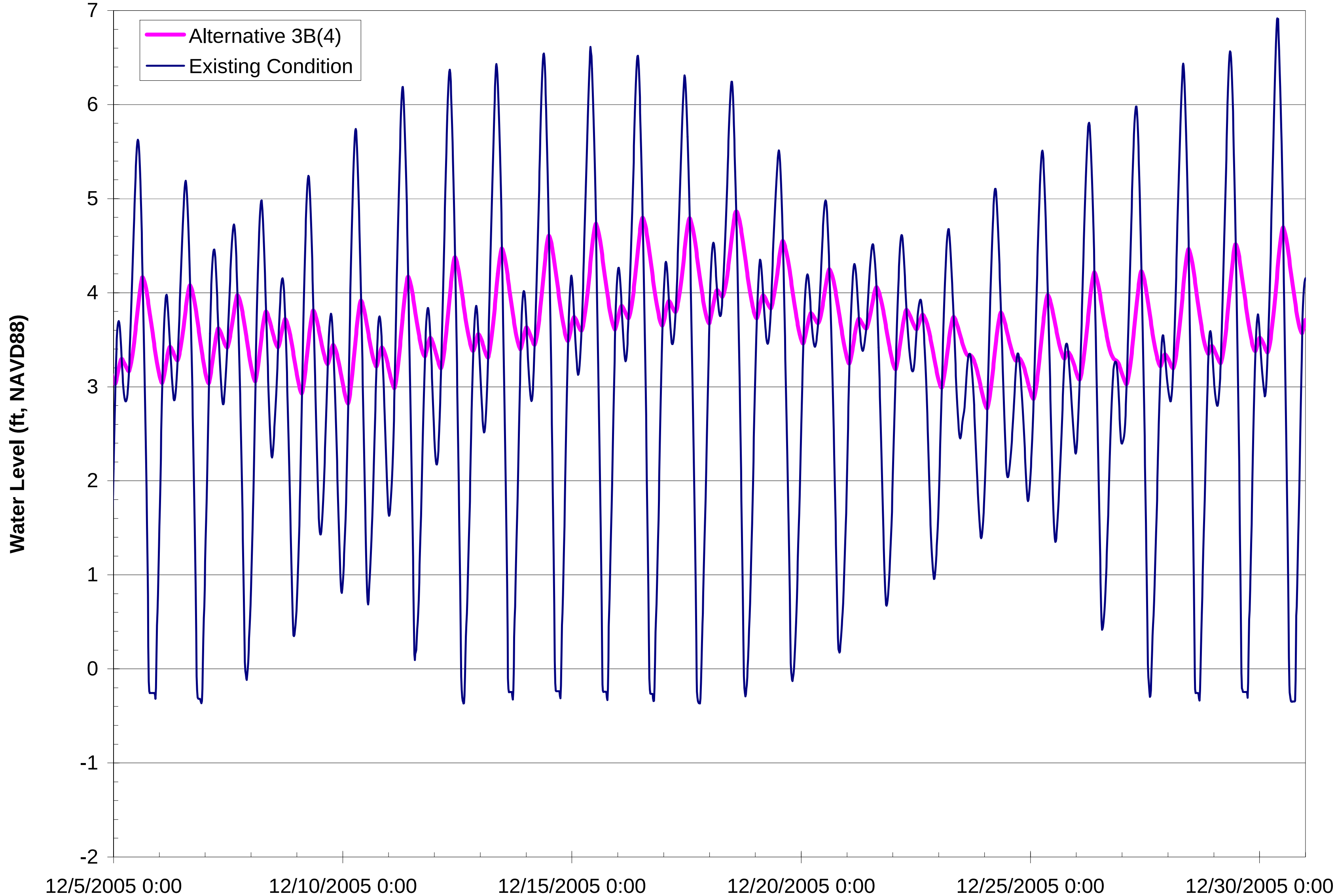


Figure 3-20 - Tidal Elevation Curve for Internal Muting Subalternative 3B(4)

3.4.1.2. Inundation Frequencies

The model results were converted into tidal inundation frequencies to quantify the time that certain elevations at the site are inundated with seawater. This factor directly affects formation of vegetated salt marsh. Vegetated marsh areas typically colonize areas that experience inundation by tides from between 6% to 20% of the time as a guideline (Moffatt & Nichol, 2004). Inundation frequency is expressed visually as a curve showing the percent of inundation time plotted against elevation at the site. Analysis was done and described below for the same alternative configurations that were analyzed with the numerical model including:

- No Project – Existing conditions.
- Alternative 1 – Structure Only, with no subalternatives of fill to isolate effects of the structure.
- Alternative 2 – Sill, with no subalternatives with fill to isolate effects of the sill.
- Alternative 2 – Sill, with all areas filled (subalternatives 2A through 2E inclusive) to test effects of large-scale fill.
- Alternative 3, Subalternatives B (muting options 1-4) – Internal Muting, with all muting options for the Five Fingers subarea used as a representative example to limit the number of model runs and iterations to within budget. The no muting option (5) would result in inundation frequencies that are the same as Alternative 2 (A-E).

Inundation frequency curves for each alternative are shown in Appendix 3-A.

3.4.1.2.1. No Project

Existing hydrologic conditions of inundation frequency from measured tide data suggest that vegetated salt marsh should exist at elevations from approximately +4.3 to +5.3 feet (+1.31 to +1.61 m) NAVD. These values bracket the measurements by the ESNERR that vegetated marsh is concentrated at elevations between +4.6 and +5.1 feet (+1.40 and +1.55 m) NAVD, with sparse vegetation down to 4.1 feet (1.24m) in full tidal areas (Van Dyke, 2008). Differences in predicted versus measured elevations can possibly be attributed to site-specific biogeochemical conditions. The main point of this information is that for the No Project Alternative the site would be largely unvegetated because the vast majority of the site is below an elevation of 4.3 feet (1.31 m) NAVD. Approximately 96% of the site is habitat other than vegetated marsh and, therefore the site experiences either too much or too little inundation. Only 17 acres (6.88 hectares) of the site are vegetated salt marsh habitat.

3.4.1.2.2. Alternative 1 – Structure Only

Alternative 1 would result in tidal muting sufficient to change the inundation frequency of areas that can support marsh, thus shifting the elevations of suitable areas for marsh downward to approximately between +2 feet and +3 feet (+0.60 and +0.90 m) NAVD. This condition would result in up to 55 acres (22.25 ha) of vegetated marsh if all areas at this elevation range were colonized. However, there is concern that the root zones of plants may not dry out sufficiently between tides to allow for colonization of the site because the tidal range is compressed. This degree of tidal muting may be excessive and prohibitive to plant establishment, thus the ability for vegetation to colonize the site is still uncertain and needs to be further investigated if this alternative were to move forward.

3.4.1.2.3. Alternative 2 – Sill With Fill (2A-2E) and Without Fill (2 Only)

Alternative 2 consists of the primary alternative of a sill across the entrance channel with a full tide range, coupled with fill throughout the entire site to raise the grade to establish vegetated marsh. The sill with no fill will not have a discernible effect on tides and does not result in modified inundation frequencies from existing conditions.

The sill with fill does have a significant effect on inundation frequencies. Alternative 2 with large-scale fill would result in the site being raised so large areas would lie at elevations appropriate for colonization of vegetated salt marsh. This action could lead to establishment of approximately 276 additional acres (111.69 ha) of vegetated marsh if all other biogeochemical conditions were suitable.

The scenario of filling with no muting for Alternative 2 is the same as Alternative 3B(5) which calls for filling of the Five Fingers and no muting. This option would also result in the site being elevated so large areas could support up to 85 acres (34.4 ha) of vegetated salt marsh. This action could lead to establishment of approximately 276 additional acres (111.69 ha) of vegetated marsh if all other biogeochemical conditions were suitable.

3.4.1.2.4. Alternative 3 - Subalternatives B(1-4) – Internal Dikes and Muting at the Five Fingers

Several subalternatives for tidal conditions are envisioned under Alternative 3. The tidal inundation frequencies for the range of subalternatives are discussed below. The no muting option of subalternative B(5) is addressed in the preceding paragraph.

- Subalternative 3B(1) - extreme muting of the high tide in the Five Fingers, targeted as a 1 foot tide range from +1 foot to 0 feet (+0.3 to 0m) NAVD representing no sediment additions: The inundation frequency would be truncated and vegetated marsh would occur at an elevation range from +0.8 to +1.1 feet (+0.24 to +0.33m) NAVD (4 inches/0.1 m). The tide range is so narrow that providing for adequate drainage of the root zone would be a problem. However, vegetated marsh exists at the 180-acre (72.84-ha) Inner Bolsa site in Southern California that possesses a 1.5 foot (0.46 m) tide range so it may be possible. Slopes would need to be extremely flat at this elevation range to provide for any appreciable area of new habitat. The Parsons Complex is extremely flat at the elevation range of between 0 and +1 foot (0 to +0.3 m) NAVD at the

Five Fingers, so a large area of vegetated marsh could potentially exist at the site. Habitat areas are not estimated for this scenario.

- Subalternative 3B(2) - significant high tidal muting in the Five Fingers with a tide range from +2 feet to 0 feet (+0.6 to 0 m) NAVD representing very limited sediment additions: The inundation frequency is also truncated to show vegetated marsh occurring at an elevation range from +1.4 to +1.7 feet (+0.43 to +0.52 m) NAVD (also 4 inches/0.1 m). However, the tide range is still very narrow, so providing for adequate drainage of the root zone could be a problem. Slopes would still need to be extremely flat at this elevation range to allow for formation of appreciable new habitat area, and the Five Fingers possesses this condition so large areas of vegetated marsh could form. Habitat areas are not estimated for this scenario.

- Subalternative 3B(3) - moderate high tide muting in the Five Fingers and 6th Finger with a tide range from +4 feet to 0 feet (+1.22 to 0 m) NAVD: The inundation frequency would also be truncated to cause vegetated marsh to occur at an elevation range from +3.25 to +4.0 feet (+0.99 to +1.22 m) NAVD (8.5 inches/0.21 m). The tide range would be broader than the previous subalternatives, so providing for adequate drainage of the root zone would be more feasible. Slopes would need to be fairly flat at this elevation range to provide for appreciable new habitat area. The Five Fingers and 6th Finger do not possess this condition at this elevation so large increases in habitat area may not form. Subalternative 3B(3) is applicable to the 6th Finger in addition to the Five Fingers. Habitat areas are not estimated for this scenario.

- Subalternative 3B(4) - muting of both the high and low tides symmetrically about mean sea level, with a tide range from +4 feet NAVD to +2 feet NAVD (+1.22 m to 0.60 m) in the Five Fingers and 6th Finger: The inundation frequency would be less truncated and cause vegetated marsh to occur at an elevation range from +4.00 to +4.50 feet (+1.22 to +1.37 m) NAVD (6 inches/0.15 m). The tide range would still be fairly narrow at 2 feet (0.60 m), so providing for adequate drainage of the root zone would still be a concern. Slopes would need to be relatively flat at this elevation range to provide for appreciable new habitat area, but the Five Fingers does not possess this condition so large areas of vegetated marsh may not become established. Habitat areas are not estimated for this scenario. Subalternative 3B(4) is also applicable to the 6th Finger.

3.4.1.3. Tidal Prism

Tidal prism is an important variable to consider for wetland evolution. It affects tidal flow velocity, channel scour, wetland geomorphology, and water residence time (an indirect indicator of water quality). The existing tidal prism is relatively large for the site because it is low-lying, and the tidal prism is gradually increasing suggesting the site is gradually lowering while tidal elevations are gradually rising. Reducing tidal prism in the Parsons Complex and overall Elkhorn Slough is a desired effect for restoration to reduce wetland losses. The tidal prism of the alternatives was determined by the model. As expected, tidal prisms vary widely depending on the degree of muting achieved. Tidal prisms for respective alternatives are shown in Table 3-3. For Alternative 3, the Five Fingers is listed as it contains the greatest tidal prism and potential for reduction. The no muting option for Alternative 3 is not specifically addressed, but the discussion for subalternatives of Alternative 2 addresses the no muting with fill scenarios.

Alternative 1 immediately reduces tidal prism through large-scale tidal muting. Alternative 3, Subalternatives B(1-4) also have an immediate effect, though not as great and delayed in time to correspond to the timing of diking and muting. Alternative 2 also reduces tidal prism over time, but by sediment additions and benefits would be realized over the long-term. Filling subareas of Alternative 2 could incrementally decrease tidal prism. Table 3-4 shows tidal prism reduction versus the fill volume needed to establish vegetated marsh habitat. Alternative 3 subalternatives result in similar reductions in tidal prism although they propose significant differences in tidal range. This effect occurs because subalternatives with less muting (and less reduction of tidal prism) propose more fill to raise wetland up to the appropriate elevation, thus filling the tidal prism band with sediment. Conversely, subalternatives with more muting (and more reduction of tidal prism) propose less fill for habitat thus filling less of the tidal prism.

3.4.1.3.1. Tidal Flow Velocities

Tidal flow velocities are important to consider with regard to sediment transport, erosion, and sedimentation. Comparison of predicted tidal flow velocities for the alternatives during maximum spring tides is presented below and shown in Table 3-5. The location of comparison for existing and predicted tidal flow velocities is at approximately 200 feet (60.9 m) north (downstream) of the UPRR bridge within the main entrance channel. Predicted maximum spring tidal flow velocities are depth-averaged by the model at one point within the entrance channel cross-section. Existing conditions are characterized by high tidal flow velocities in both ebb (outflow) and flood (inflow) directions. High flow velocities would continue to induce scour and extend wetland losses farther into the Parsons Complex. Reducing tidal flow velocities would reduce erosion and marsh loss. All actions would result in a system that would be ebb-tide dominant, meaning that tidal outflows would be higher in velocity and sediment transport capacity than tidal inflows. The literature indicates that erosive conditions occur when flow velocities reach approximately 1.1 foot per second (fps) (0.33 meters per second (m/s) for fine sand and 3 fps (1.1 m/s) and higher for coarse sand and silts/clays (see the URL http://www.gly.fsu.edu/~holm/2010/Hjulstrom.html for the diagram showing the relationship of flow velocity and erosion). The bed of the Parsons Complex is mainly composed of silts and clays.

3.4.1.3.2. No Project

Existing conditions of high flow velocities will remain under the No Project Alternative. Tidal flow velocities in certain areas of the Parsons Complex are sufficiently high to induce scour. The main entrance channel is the location of greatest scour, having eroded to a maximum depth of approximately -20 feet (-6.09 m) NAVD under the UPRR bridge, and remaining deep (-10 feet/-3.04 m NAVD) extending into the "palm," or central area, of the Five Fingers. High tidal flow velocities at the UPRR bridge have been measured and are approximately 5.5 feet per

Table 3-3 – Tidal Prisms of Each Alternative

Alternative	Tidal Prism		Reduction in Tidal Prism	
	Million Cubic Feet, mcf	Million Cubic Meters, mcm	Million Cubic Feet, mcf	Percentages, %
No Project	78.2	2.2	0	0%
1 – Structure Only	19.5	0.6	58.7	75%
2 – Sill With 2.3 Million Cubic Yards of Fill (2A – 2E)	29.5	0.8	48.7	62%
3 Subalternative B(1) – Extreme Muting	54.8	1.6	23.4	30%
3 Subalternative B(2) – Significant Muting	54.6	1.5	23.6	30%
3 Subalternative B(3) – Moderate Muting	56.5	1.6	21.7	28%
3 Subalternative B(4) – Symmetrical Muting	55.8	1.6	22.4	29%

Table 3-4 – Incremental Tidal Prism Reduction and Fill Volumes for Alternative 2

Subarea	Fill Volume Needed to Establish Vegetated Marsh (cubic yards)	Existing Tidal Prism		Tidal Prism Reduction to the Parsons Complex	
		Million Cubic Feet, mcf	%	Million Cubic Feet, mcf	%
6th Finger (2A)	124,100	4.4	6%	2.3	3%
Five Fingers (2B)	717,500	23.8	30%	14.9	19%
South Marsh Restoration Cells (2C)	142,300	4.6	6%	2.9	4%
Rookery Lagoon (2D)	151,400	4.6	6%	3.2	4%
All Other Areas (2E)	1,203,100	40.5	52%	25.3	32%
Total	**2,338,400**	**78.2**	**100%**	**48.7**	**62%**

* Data in this Table apply to Alternative 3, Subalternatives A-E(5).

second (1.7 m/s) on outgoing tides, and 5.0 feet per second (1.5 m/s) on incoming tides (Broenkow and Breaker, 2005). Previous modeling by PWA (2007) predicted tidal flow velocities to reach 3.3 feet per second (1.0 m/s) for ebbing tides and 1.6 feet per second (0.49 m/s) for incoming tides. Erosive conditions would remain with the No Project Alternative.

3.4.1.3.3. Alternative 1 – Structure Only

Predicted tidal flow velocities for Alternative 1 would be reduced approximately 4-fold from existing conditions due to muting. High flow velocities were predicted as 1.4 fps (0.42 m/s) on ebbing tides and 1.3 fps (0.39 m/s) on flooding tides. This alternative should reduce the magnitude of existing erosive conditions.

3.4.1.3.4. Alternative 2 – Sill With Fill (2A – 2E) and Without Fill (2 Only)

Initially, Alternative 2 without fill will slightly reduce flow velocities away from the sill before any large-scale fills occur. This occurs with no change in tidal prism because the duration of the ebbing tide is increased under this option allowing complete tidal exchange and preservation of the tidal prism. This option may increase flow velocities right at the crest of the sill under certain conditions (during maximum spring tides). This would be a result of the cross-sectional area of the main entrance channel being constricted by the sill, while the existing tidal discharge during each tide cycle continues to be conveyed through the channel.

For the sill with fill condition, tidal flow velocities through the entrance channel and over the sill would be reduced from existing velocities after substantial filling with 2.3 million cubic yards occurs over the long-term. The modeling shows that peak flow velocities for ultimate filled conditions drop to 2.0 fps (0.6 m/s) for ebbing tides and 1.2 fps (0.36 m/s) for flooding tides. Erosive conditions in the entrance channel could still occur under peak flow ebb tide conditions under Alternative 2, however, its magnitude will be reduced from existing conditions.

3.4.1.3.5. Alternative 3 - Subalternatives B(1-4) – Internal Dikes and Muting

All of the tidal muting options of Alternative 3, Subalternative B with the Five Fingers presented herein as a representative example, would result in a reduction to predicted tidal flow velocities through the entrance channel to the Parsons Complex. Reduced flow velocities will enable sediments to remain in the Complex longer and reduce losses. The no muting option (5) of Subalternative 3B was not modeled, so flow velocity predictions do not exist. Velocities for subalternative 3 B(5) will be the same as for the Alternative 2 with no fill option and should decrease in magnitude.

Subalternative B(1) – Extreme Muting – Extreme muting would reduce tidal discharges through the entrance channel sufficiently for predicted flow velocities to drop to values of 2.3 fps (0.7

m/s) for ebb tides and 1.3 fps (0.39 m/s) for flood tides. Subalternative 3B1 may reduce the magnitude of existing erosive conditions, but not eliminate erosion entirely.

Subalternative B(2) – Significant Muting – Significant muting would also reduce tidal discharges through the entrance sufficiently for predicted flow velocities to drop to values of 2.3 fps (0.7 m/s) for ebb tides and 1.3 fps (0.39 m/s) for flood tides. Subalternative 3B2 may reduce the magnitude of existing erosive conditions, but not eliminate erosion entirely.

Subalternative B(3) – Moderate Muting – Moderate muting would also reduce tidal discharges through the entrance sufficiently for predicted flow velocities to drop to values of 2.4 fps (0.73 m/s) for ebb tides and 1.3 fps (0.39 m/s) for flood tides. Subalternative 3B3 may reduce the magnitude of existing erosive conditions, but not eliminate erosion entirely.

Subalternative B(4) – Symmetrical Muting – Symmetrical muting would also reduce tidal discharges through the entrance the same as for the other options for predicted flow velocities to drop to values of 2.3 fps (0.7 m/s) for ebb tides and 1.3 fps (0.39 m/s) for flood tides. Subalternative 3B4 may reduce the magnitude of existing erosive conditions, but not eliminate erosion entirely.

Table 3-5 – Predicted Peak Tidal Flow Velocities for Each Alternative and Muting Subalternative

Alternative	Peak Ebb Velocity		Peak Flood Velocity	
	Fps	**m/s**	**fps**	**m/s**
Existing (No Project)	5.5*	1.68*	5.0	1.52*
1 - Structure Only	1.4	0.42	1.3	0.39
2 - Sill Without Fills	3.1	0.94	1.7	0.51
2 - Sill With Fills (2A-2E)	2.0	0.6	1.2	0.36
3 - Subalternative B(1)	2.3	0.7	1.3	0.39
3 - Subalternative B(2)	2.3	0.7	1.3	0.39
3 - Subalternative B(3)	2.4	0.73	1.3	0.39
3 - Subalternative B(4)	2.3	0.70	1.3	0.39

** Measured value.*

3.4.1.4. Effectiveness of the Sill in Alternative 2

The sill envisioned near the UPRR Bridge for Alternative 2 is intended to perform the following two functions:

- Prevent potential headcutting within the main Parsons entrance channel from propagating upstream farther than it may presently exist and;
- Retain sediments added within Parsons to reduce their rate of loss.

Planning whether or not to include the sill may hinge on the beneficial effects the sill may have on channel erosion in Elkhorn Slough and the Parsons Complex. The present understanding is that the sill would also be effective at reducing tidal scour in the main channel of Elkhorn Slough if it substantially reduces peak velocity, even though it does not affect tidal prism.

It was not originally intended to reduce tidal prism or tidal flow velocities on its own without significant additions of fill within the Parsons Complex. However, the sill without any fill may potentially reduce tidal prism and flow velocities. Considerations associated with the sill are listed below.

<u>Retention:</u>

- Sediment added to the Parsons Complex might bypass the sill;
- Sediment exported from the Parsons Complex might benefit other parts of Elkhorn Slough that are sediment starved;
- The sill serves as a retaining wall for bed sediment.

<u>Erosion:</u>

- The sill potentially reduces peak current velocity;
- The sill reduces/prevents further channel incision (headcutting) in Parsons;
- Channel erosion in Elkhorn Slough might be unaffected by a sill;
- Channel erosion from tidal scour in the Parsons Complex might continue with a sill; and
- Effects of the sill on tidal flow velocity throughout the tidal cycle and on tidal scour.

<u>Costs:</u>

- The sill is relatively inexpensive compared to other project costs and may have substantial benefits; and
- The sill is an added project expense beyond sediment additions.

<u>Impacts:</u>

- The sill may affect animal migration (though not as bad as culverts); and
- The sill may affect water quality (though not as bad as culverts, it may induce stratification);

In order to determine whether the sill would result in these effects, studies are recommended to address the processes of channel incision at Parsons, and tidal flow velocities within Elkhorn

Slough and the Parsons Complex relative to the sill, respectively. Both analyses are described below.

3.4.1.4.1. Effect of the Sill on Current Velocities and Erosion in Parsons and Elkhorn

Evaluation of Velocities Using DELFT

The DELFT 3D model was used to compare flow velocities within the Parsons Complex and within the main Elkhorn Channel with and without the sill for Alternative 2. The model was also used to estimate any changes in tidal prism within the Parsons Complex resulting from installing the sill. Tidal flow velocities were analyzed at four points in channels as shown in Figure 3-21. Points are both within and outside of (within the main Elkhorn Slough channel) the Parsons Complex. Tides are an actual recorded cycle in December 2005 and include both neap and spring conditions. The maximum spring tide that occurs less than 5% of the time was also included during that period. Peak tidal flow velocities occur during the maximum spring tide and are analyzed below. Results of tidal flow velocity changes are presented in Tables 3-5 and 3-6 and Figures 3-22 through 3-25, and are discussed below. Existing tidal flow velocities are provided by the model and could be verified in the field by tracking simple drogues or installing gages.

Figures 3-22 through 3-25 show tidal elevations and current speed at the four points shown in Figure 3-21 over a two-week period during extreme spring tides for the full-width sill. The thresholds of erosion are shown for varying sediment grain sizes. Sediment grain sizes at the Parsons Complex are mainly silts and clays, and require a velocity of approximately 3 feet per second for mobilization. Sediment grain sizes in the Main Elkhorn Slough Channel vary between fine to medium sand, and require lower velocities for mobilization. The figures show that tidal flow velocities are not sufficient to induce scour at the Parsons sites, but are sufficient to cause scour at the Main Elkhorn Slough Channel.

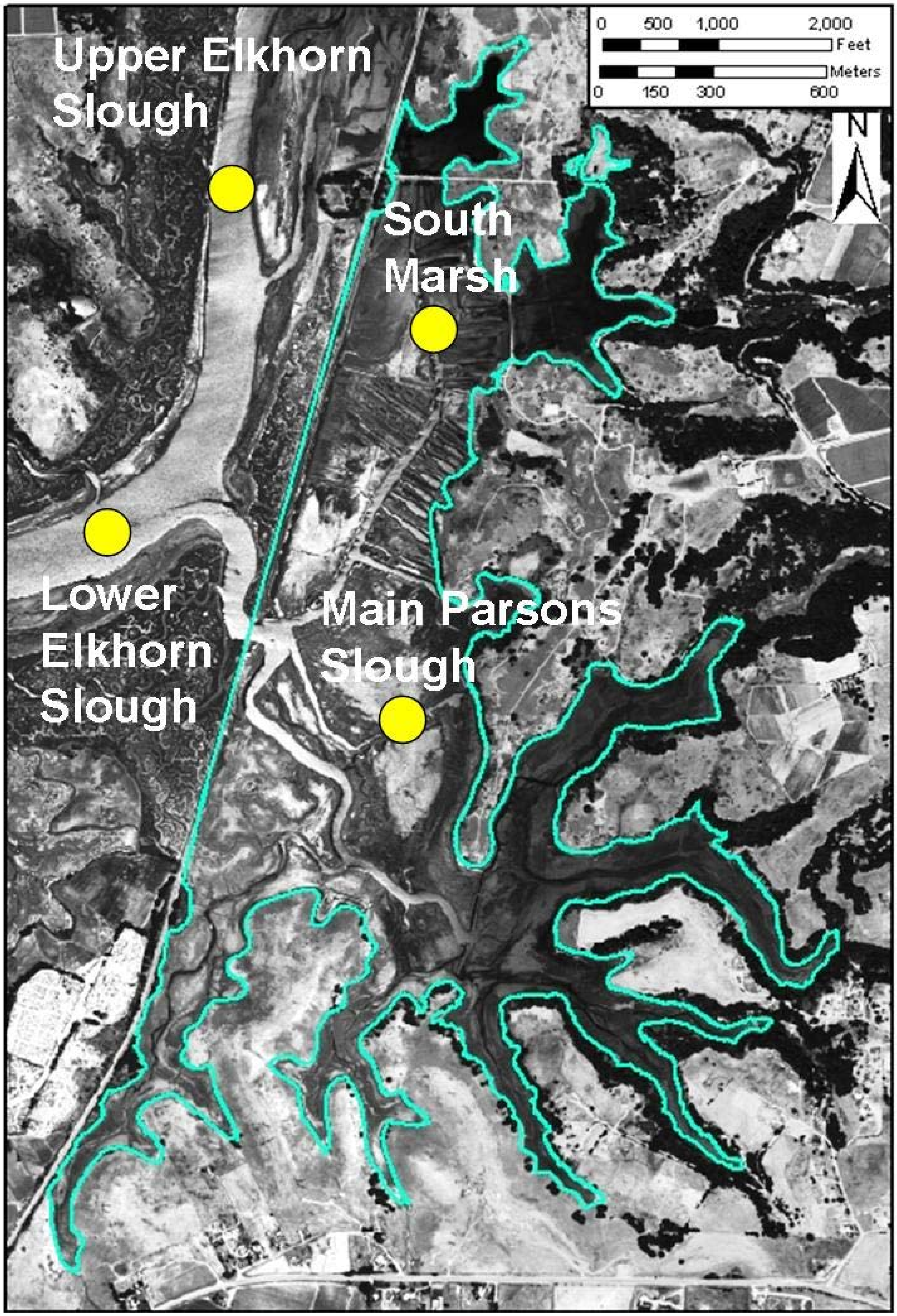


Figure 3-21 – Tidal Flow Velocity Model Output Points

Table 3-6 – Tidal Flow Velocities in Wetland Areas with the Full Sill Width

Location	PEAK TIDAL FLOW VELOCITIES AND PERCENT CHANGES					
	Existing Conditions		Alternative 2 Sill (Full Width)			
	Velocity **Ebb Flow** feet per second	**Velocity** **Flood Flow** feet per second	**Velocity** **Ebb Flow** feet per second	**Ebb Flow Maximum Change from Existing** Percent	**Velocity** **Flood Flow** feet per second	**Flood Flow Maximum Change from Existing** Percent
South Marsh (Just West of the Rookery)	1.0	1.2	0.9	-13%	1.2	1%
Direction of Peak Flows		Flooding Tide			Flooding Tide	
Main Parsons (Just West of the Five Fingers)	0.7	0.8	0.6	-18%	0.8	0%
Direction of Peak Flows		Flooding Tide			Flooding Tide	
Elkhorn Main Channel (Just West and Downstream of Parsons Main Channel)	3.4	1.9	3.3	-3%	1.9	-1%
Direction of Peak Flows	Ebbing Tide		Ebbing Tide			
Elkhorn Main Channel (1 Mile Upstream of Parsons Main Entrance Channel)	2.5	1.0	2.6	5%	1.0	0%
Direction of Peak Flows	Ebbing Tide		Ebbing Tide			

Table 3-7 – Tidal Flow Velocities in Wetland Areas with the Constricted Sill

Location	PEAK TIDAL FLOW VELOCITIES AND PERCENT CHANGES					
	Existing Conditions		Alternative 2 Constricted Sill			
	Velocity **Ebb Flow** feet per second	**Velocity** **Flood Flow** feet per second	**Velocity** **Ebb Flow** feet per second	**Ebb Flow Maximum Change from Existing** Percent	**Velocity** **Flood Flow** feet per second	**Flood Flow Maximum Change from Existing** Percent
South Marsh (Just West of the Rookery)	1.0	1.2	0.6	-40%	1.2	2%
Direction of Peak Flows		Flooding Tide			Flooding Tide	
Main Parsons (Just West of the Five Fingers)	0.7	0.8	0.4	-49%	0.7	-12%
Direction of Peak Flows		Flooding Tide			Flooding Tide	
Elkhorn Main Channel (Just West and Downstream of Parsons Main Channel)	3.4	1.9	2.7	-21%	1.0	-47%
Direction of Peak Flows	Ebbing Tide		Ebbing Tide			
Elkhorn Main Channel (1 Mile Upstream of Parsons Main Entrance Channel)	2.5	1.0	2.7	8%	1.0	-1%
Direction of Peak Flows	Ebbing Tide		Ebbing Tide			

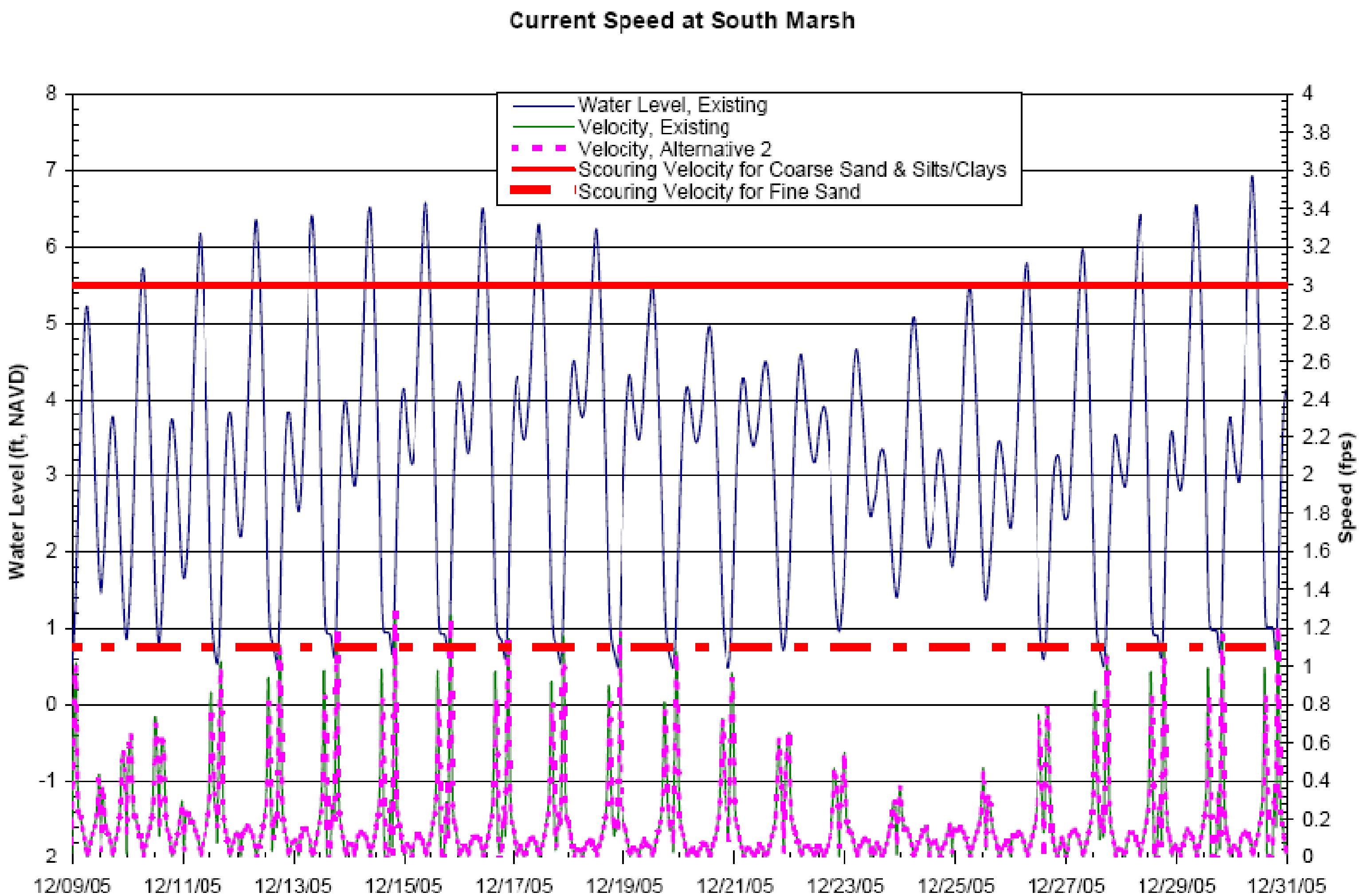


Figure 3-22 – Current Speed and Tidal Elevation at South Marsh

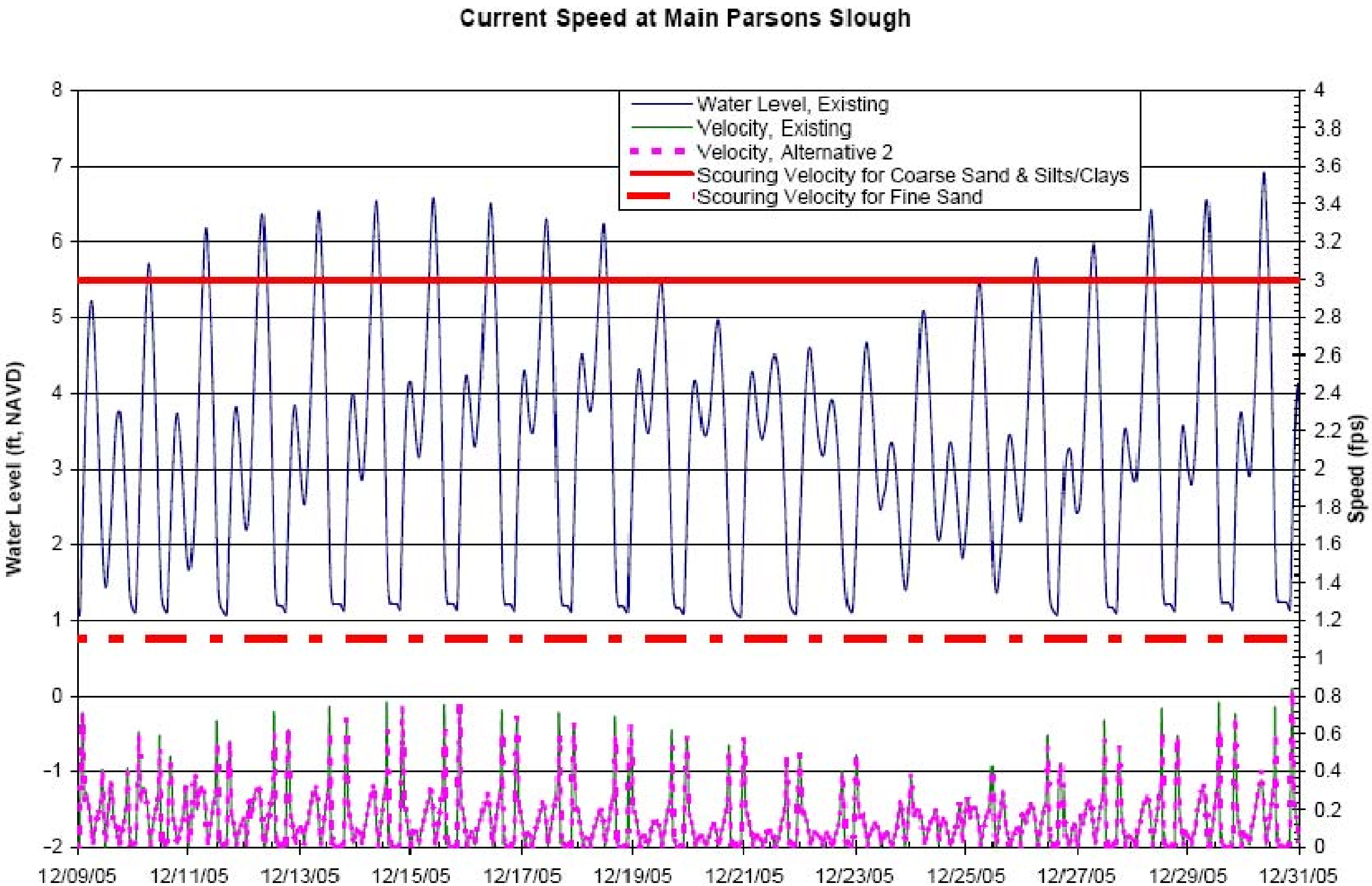


Figure 3-23 – Current Speed and Tidal Elevation at Main Parsons Slough

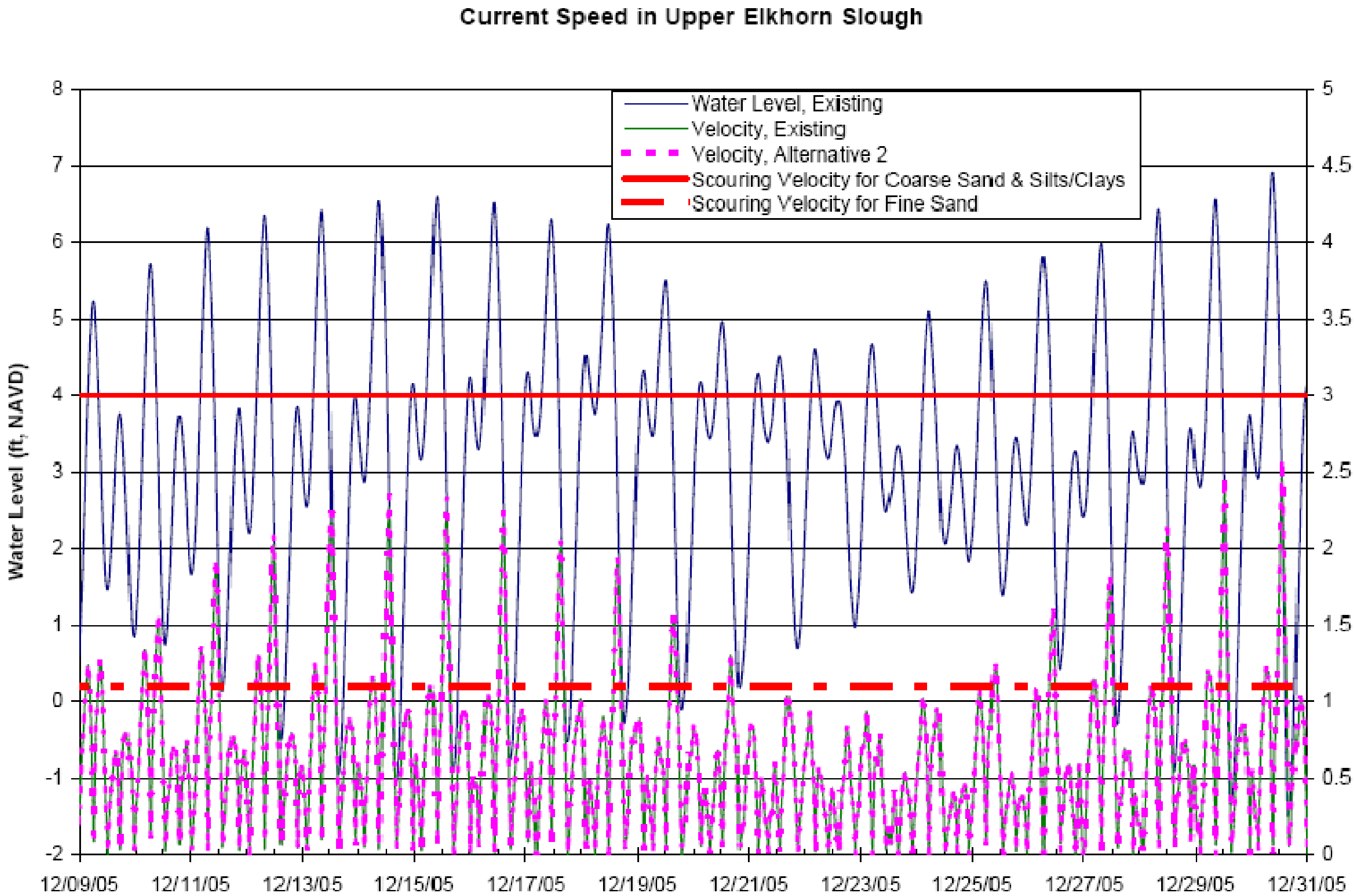


Figure 3-24 – Current Speed and Tidal Elevation in Upper Elkhorn Slough

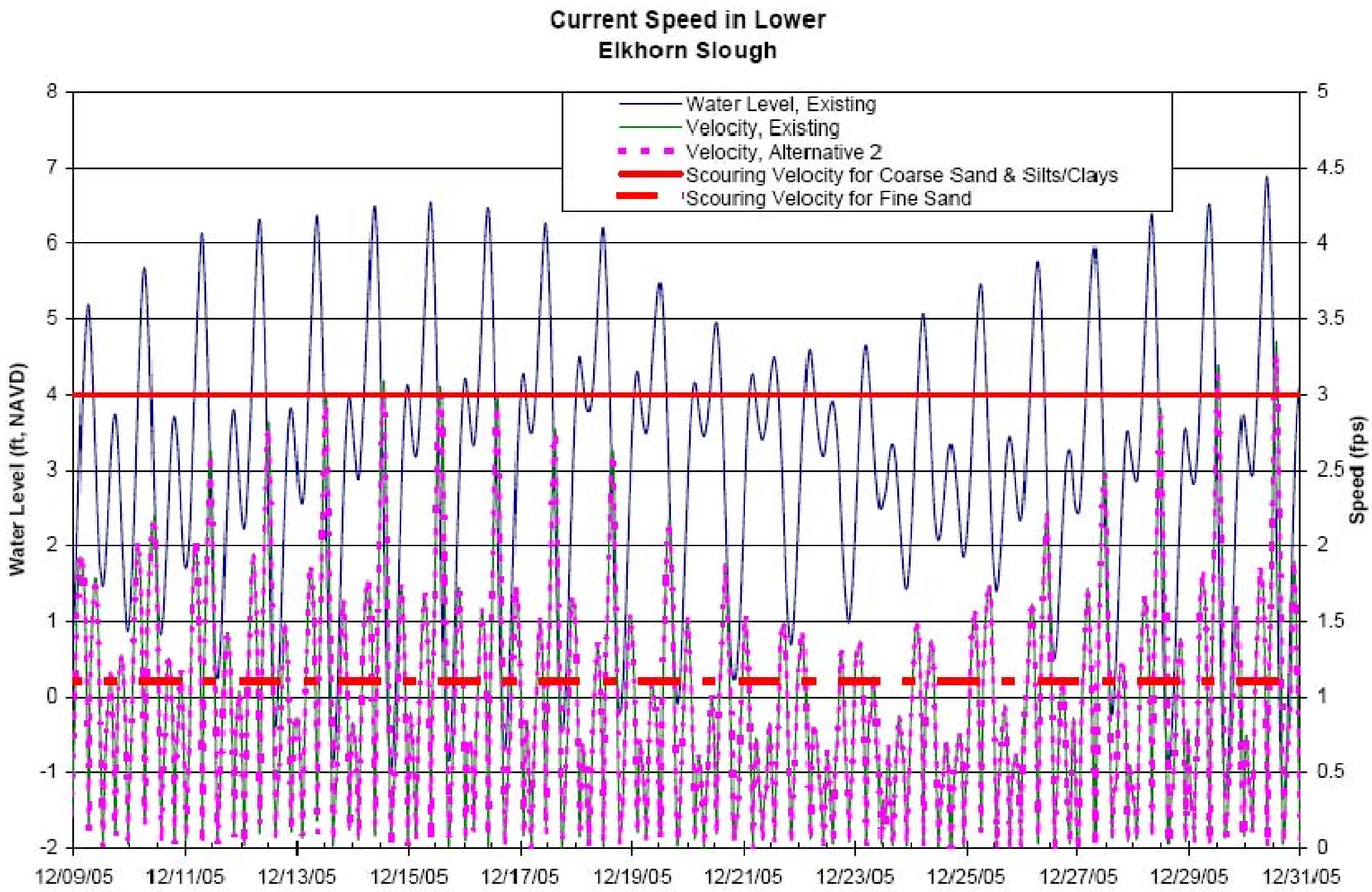


Figure 3-25 – Current Speed and Tidal Elevation in Lower Elkhorn Slough

Peak Tidal Flow Velocities – Full Width Sill

The basic sill is mainly intended for sediment retention and channel bed anchoring and was not intentionally designed to reduce the tidal flow velocities. However, the existing sill concept does decrease tidal flow velocities within the Parsons Complex and within a portion of the main channel at Elkhorn Slough. Table 3-5 shows that maximum tidal flow velocities within the Parsons Complex occur during flooding tides, with similar but slightly reduced velocities during ebbing tides. Peak flood tidal flow velocities are approximately 20% higher than peak ebb tidal flow velocities. Effects of the sill are that flood tidal flow velocities remain nearly constant near the Rookery, and drop within the lower area of Parsons near the Five Fingers. Ebb tidal flow velocities within the Parsons Complex consistently decrease.

Within the main channel at Elkhorn Slough, tidal flow velocities are also affected but to a lesser degree. Tidal flow velocities within Elkhorn Slough main channel are significantly higher on ebbing tides. The sill causes peak ebb tidal flow velocities to slightly decrease downstream of the main Parsons Complex entrance channel. Upstream of the main Parsons Complex entrance channel the sill causes peak tidal flow velocities to *increase*. The sill results in a slight variation in water levels within the main channel at Elkhorn Slough between locations upstream and downstream of main Parsons Complex entrance channel. This effect is caused by a slight lag in the ebbing tide from Parsons and a slight "piling up" of water behind the sill within Parsons. This retention of water in Parsons during ebbing tides reduces the tidal discharge downstream within the main channel at Elkhorn Slough and thus tidal flow velocities. However, this water level variation also results in a sufficient change in the hydraulic gradient along the main channel at Elkhorn Slough near Parsons to cause flow velocities to locally increase upstream of the main Parsons Complex entrance channel.

Peak Tidal Flow Velocities – Constricted Sill

Alternative 2 with a narrowed channel over the sill and without filling of the Parsons Complex results in ebb tidal velocities within the Parsons Complex decreasing more significantly near the Rookery and Lower Parsons Complex. Table 3-6 shows values for flow velocities under this scenario. Flood tidal flow velocities slightly increased near the Rookery and decreased in Lower Parsons. Within the main channel at Elkhorn Slough results were more pronounced, with a reduction in ebb tidal flow velocities downstream of the Parsons channel and an *increase* in velocities one mile upstream of the Parsons channel.

Ebb Versus Flood Tidal Flow Velocities

The ebb tidal flows within the Parsons and Elkhorn systems may be more critical to consider than flood tidal flows. Ebbing tidal currents are the mechanisms for expelling sediment from the system resulting in permanent losses. Tidal flooding currents may erode sediment if their velocities are high enough, but they may result in a redistribution of sediment within the wetland areas rather than losses from the systems. Therefore, although flood tidal flow velocities within Parsons are higher than ebb flow velocities, they do not likely represent a concern for sediment scour and loss of salt marsh habitat.

Reductions to tidal ebb flow current velocities are key to reducing marsh losses in both the Parsons Complex and Elkhorn Slough. Modeling results suggest that ebbing tidal flow velocities for areas upstream of the sill (all of the Parsons Complex) will experience reduced tidal flow velocities with the sill in place. This result also occurs at areas within the Elkhorn Slough main channel downstream of the confluence with the Parsons main channel. It is also assumed that areas within the main Elkhorn Slough channel upstream of the confluence with the Parsons main entrance channel will experience a slight increase in ebbing tidal flow velocities from installing the sill.

Tidal Prism

The model results show no discernable reduction to the tidal prism with the sill as it is presently designed. Peak tidal flow velocities decrease with the sill in place, but the duration of ebbing tides increases over a given tidal cycle thus maintaining the existing tidal prism.

The sill was not designed to reduce tidal prism directly. However, modifications can be made to the sill to cause tidal prism to be reduced. Design modifications to the sill to reduce tidal prism would have to show narrowing of the cross-section of the channel at the sill greater than 50%.

Effects on Erosion

Reduction of all tidal flow velocities within the Parsons Complex will reduce tidal scour and erosion of sediment, and particularly expulsion of sediment from the system. Also, reduction of ebb tidal flow velocities within the lower main channel of Elkhorn Slough will more significantly reduce tidal scour and erosion from all areas downstream of the confluence with the Parsons Complex. These beneficial effects will be further pronounced if the entrance channel at the sill at Parsons is reduced in width by 50%. The sill structure being considered for installation at the downstream end of Elkhorn Slough could negate the effect of increased ebb flow velocities upstream of the confluence.

3.4.1.4.2. Mechanisms of Channel Erosion/Incision at Parsons

One of the most significant processes that may affect the Parsons Complex, and potentially any alternatives to restore the site, is possible headcutting of the entrance channel extending from Elkhorn Slough. The existence of channel headcutting at Parsons is not proven, but is suspected and hypothesized by Moffatt & Nichol (2007). Increasing the understanding of possible headcutting by researching bathymetric changes, bed sediment composition, and erosion/sedimentation processes within the Parsons Complex can be addressed by further study.

A study of potential entrance channel headcutting could be done by Cal State University Monterey Bay (CSUMB) in collaboration with the ESNERR. The study could identify the mechanisms of channel erosion/incision at the Parsons Complex and assess potential solutions to arrest excessive sediment loss. A main objective could be to verify any headcutting or alternate processes, such as tidal scour, occurring within channels on-site. Results could be applied to assess the suitability of a sill at the entrance channel as a component of a restoration alternative.

3.4.1.4.3. Implementation of the Sill

This plan recommends installing the sill as part of restoration, based on modeling results indicating the sill reduces ebb tidal flow velocities within the Parsons Complex and lower Elkhorn Slough. The sill could be installed either as an initial restoration action or at a later stage of restoration with equal success. The timing of sill installation will likely depend on available funding and the anticipated rate of sediment additions over time.

Installing the sill as an initial restoration action could occur if funding were available and the Parsons Restoration Team anticipated potential large-scale sediment additions (1 million cubic yards or more) over the short-term, such as ten to fifteen years (by 2018 to 2023). Alternatively, the sill could be deferred until a later stage of restoration if funding were limited and only relatively small-scale sediment additions (less than 1 million cubic yards) were anticipated over the next ten to fifteen years.

Allowing more time prior to sill installation would enable evaluation of monitoring data of restoration actions at Parsons to inform later restoration stages and actions. Providing more time prior to sill installation at Parsons could also allow for resolution of restoration actions at Elkhorn Slough, and their consideration in final design of the Parsons sill. Thus, it is recommended to implement the sill at a later stage of restoration unless adequate funding was available over the short-term for early implementation.

3.4.2. Water Quality

For purposes of this analysis, tidal water residence time in the Parsons Complex was used as a surrogate, or indirect indicator of water quality. Typically, water quality is directly related to water residence time at a site (i.e., tidal flushing), assuming no significant inputs of pollutants are contributed from outside of the system. A site that possesses seawater and that does not experience tidal flushing will stagnate, stratify, elevate in temperature, and lose its oxygen. Stagnant conditions can also lead to build-up of organic wastes, nutrients, and sulfur in sediment and can eventually lead to eutrophication. Such conditions are inhospitable to most marine life and lead to a significantly degraded ecosystem condition.

Seawater residence time is expressed in days, with one potential guideline of 5 days or less from ocean conditions being considered adequate to maintain water quality for salt marsh at sites in California (M. Josselyn, Personal Communication, 2008). Per Dr. Josselyn, “the best eelgrass survival and growth is in areas with a tidal residence time of less than 6 days, growth is curtailed when tidal residence time is 7-14 days—and when over 14 days, it does not survive. Eelgrass is a good indicator of high-quality subtidal habitat, and it exists in Elkhorn Slough as well.” In this instance, eelgrass is referred to as an indicator of water quality in general, thus inferring potential water quality conditions applicable to overall marsh conditions as well.

The residence time of seawater in the Complex is estimated based on hydrodynamic modeling results and analytical estimates. Residence time (RT) is estimated as follows as taken from Van de Kreeke and Larsen (1981):

$$RT = \frac{\text{Tidally Averaged Volume (mean volume)}}{\text{Tidal Prism X Tidal Exchange Coefficient}}$$

The Tidal Exchange Volume is the fraction of new water entering on the flood tide, assumed to be 0.35 as determined from the literature applied to similar sites (U.S. Army Corps of Engineers 2002).

Results are discussed below and presented in Table 3-7 for each alternative. Residence time estimates are averages over various tidal conditions, and could be shorter during spring tide cycles and longer during neap tide cycles. Values are provided for the main body of the Parsons Complex, and then at the Five Fingers as an example of a more distant area with reduced tidal flushing compared to the main body of the Parsons Complex. All residence time values are relative to conditions in Elkhorn Slough. For subalternatives with tidal muting in the various fingers, the Five Fingers is used as an example of potential effects to tidal residence times.

Table 3-8 – Tidal Residence Times For Each Alternative

Alternative	Tidal Residence Time (Days)	
	Main Body of Parsons	Five Fingers
No Project	3.2	6.6
1 – Structure Only	3.9	8.4
2 – Sill Without Fill	3.2	6.6
2 – Sill With Fill (2A – 2E)	2.9	6.1
3 - Subalternative B(1) – Extreme Muting	5.4	14
3 - Subalternative B(2) – Significant Muting	4.7	11.6
3 - Subalternative B(3) – Moderate Muting	3.7	7.2
3 - Subalternative B(4) – Symmetrical Muting	4.4	12.9

Restoration of vegetated salt marsh is likely to improve water quality conditions beyond considerations of seawater residence time. Salt marsh restoration is often justified based on its beneficial effects on water quality due to effects of uptake of nutrients, metals, and other contaminants in solution by marsh vegetation (Mitsch and Gosselink, 1986).

3.4.2.1. No Project

The residence time for the No Project Alternative is 3.2 days in the overall Parsons Complex, and 6.6 days in the Five Fingers. The overall quality is good during certain late fall, winter, and early spring seasons, with poorer water quality during late spring, summer, and early fall. South Marsh dissolved oxygen data indicate hypoxia occurs during substantial portions of the late summer and early fall (B. Largay, Personal Communication, 2008; Moffatt & Nichol, 2007). Periods of high nutrient levels also occur in spring and summer seasons, but these conditions are short-lived. Water quality is compromised seasonally within the Complex, and is therefore vulnerable to potential further impairment from reduced tidal flushing.

3.4.2.2. Alternative 1 – Structure Only

The residence time for Alternative 1 is predicted as 3.9 days in the Parsons Complex and 8.4 days in the Five Fingers, and tidal flushing is decreased throughout the Complex from existing conditions. At a minimum, water quality could potentially be impaired under conditions of high nutrient levels and low dissolved oxygen content during late spring, summer, and early fall seasons. Water quality of Alternative 1 could potentially be impaired more frequently than under existing conditions and therefore occur over longer periods and during additional seasons based on residence times.

3.4.2.3. Alternative 2 – Sill With Fill (2A – 2E) and Without Fill (2 Only)

The residence time in the Parson's Complex for Alternative 2 without fill is 3.2 days in the main Parson's Complex and 6.6 days in the Five Fingers which is the same as the existing condition with no changes.

The residence time for Alternative 2 at ultimate restoration with large-scale fills is shorter than for existing conditions and is predicted to be 2.9 days in the main body of the Parsons Complex and 6.1 days in the Five Fingers, as the tidal prism in the Complex will be reduced over the long-term. Overall water quality for Alternative 2 would improve over existing conditions over the long-term based on residence times, but would not change over the short-term.

3.4.2.4. Subalternative 3B(1) – Internal Dikes, Extreme Muting, and Fill (Assumed to be at the Five Fingers for this Analysis)

The residence time for Subalternative 3B(1) is lengthened to 5.4 days in the lower Parsons Complex, and is estimated to be 14 days in the muted area of the Five Fingers. Tidal flushing will be significantly reduced and water quality will definitely be impaired in spring/summer seasons more frequently for Subalternative 3B(1) than existing conditions. This subalternative will have the poorest water quality of any options for Alternative 3.

3.4.2.5. Subalternative 3B(2) – Internal Dikes, Significant Muting, and Fill (Assumed to be at the Five Fingers for this Analysis)

The residence time for Subalternative 3B(2) is predicted to be 4.7 days in the main body of Parsons, and 11.6 days in the Five Fingers. Tidal flushing will be reduced and water quality will be impaired in spring/summer seasons more frequently for Subalternative 3B(2) than existing conditions, but less than for Subalternative 3B(1).

3.4.2.6. Subalternative 3B(3) – Internal Dikes, Moderate Muting, and Fill (Assumed to be at the Five Fingers for this Analysis)

The residence time for Subalternative 3B(3) is estimated to be 3.7 days in main Parsons, and 7.2 days in the Five Fingers. Tidal flushing will be reduced from existing conditions and water quality will also be impaired in spring/summer more frequently for Subalternative 3B(3) but less than for Subalternative 3B(2). This subalternative will result in the best water quality of options for Alternative 3.

3.4.2.7. Subalternative 3B(4) – Internal Dikes, Symmetrical Muting, and Fill (Assumed to be at the Five Fingers for this Analysis)

The residence time for Subalternative 3B(4) is estimated as 4.4 days in the main Parsons area and 12.9 days in the Five Fingers. Tidal flushing will be reduced from existing conditions and water quality impaired in spring/summer more frequently for Subalternative 3B(4), but only less than Subalternative 3B(1).

3.4.2.8. Subalternative 3B(5) – Internal Dikes, No Muting, and Fill (Assumed at all Fingers, South Marsh, and the Rookery)

The residence times were not estimated for Subalternative 3B(5), but they will be shorter than all other Alternative 3 muting options, and will be intermediate between Alternative 2 and Subalternatives 2A-2E.

3.4.3. Sea Level Rise

A rate of sea level rise of three feet per century, consistent will future projections for this site (Moffatt & Nichol, 2007), is incorporated into the analysis of alternatives for assessment of long-term conditions. The period of analyses to be performed according to the scope of work is over a 20-year future post construction. Sea level rise of three feet (36 inches/0.9 m) per century, or approximately equal to a rate of 0.4 inches (0.01 m) per year (if assumed to be linear) is used in this report. A linear rate of sea level rise is an over-simplification, but is sufficient to use as an assumption for this level of analysis. Estimates of the actual rate of sea level rise are continually being updated, and some of the latest projections provided by the State of California indicate a rate of rise of 16 inches (0.40 m) by 2050 and 55 inches (1.39 m) by 2100 (CalFed, 2007).

Although uncertain, for purposes of this analysis the project construction end date is assumed to be 2015. The project could potentially be implemented earlier if all work proceeded with no delays, but this longer schedule assumes some additional time is needed to provide a conservative estimate. Therefore, the 20-year horizon should be approximately the year 2035, and sea level rise at the site is assumed to be 11 inches (0.27 m) above existing (2008) sea level at that time.

Alternatives assessed for effects of sea level rise include:

- No Project.
- Alternative 1 (1A – 1E).
- Alternative 2 (2A – 2E).
- Alternative 3 (3A[3] – 3E[3]).

3.4.3.1. No Project

Effects of sea level rise for the No Project Alternative are described below.

Hydrology/Hydraulics – The effect would be to elevate all tidal elevations and datums over time, including mean sea level, mean higher high water, and mean lower low water by approximately 11 inches (0.27 m). The future tide range would be from +6.67 ft (+2.03 m) to +0.69 ft (+0.21 m) MLLW. Tide ranges should remain as they presently exist.

Inundation Frequencies – As water levels progressively rise in the Complex, vertical locations of habitats will correspondingly shift upward. For example, areas that are transitional now could become high marsh, areas that are high marsh could become mudflat, and areas that are mudflat could become subtidal. The amount of habitat conversion could be significant with 11 inches (0.27 m) of sea level rise. The technical effect could be seen as a shift in the inundation frequency curve shown as figures in Appendix 3-B to the right by 11 inches (0.27 m) causing habitats to transition in vertical position by that amount.

Tidal Prism – Tidal prism will increase as the elevation band within the tidal range is progressively occupied more and more by water, assuming the wetland elevation remains constant over time while sea level rises. Sea level rise of 11 inches (0.27 m) by 2035 would increase the tidal prism to 92.4 mcf from the existing volume of 78 mcf, assuming no additional effect from on-going erosion at the site. However, the No Project Alternative will enable existing erosion to continue due to the estimated increase in tidal prism, thus potentially increasing the tidal prism further.

Flow Velocities – Tidal flow velocities throughout the marsh will increase above existing conditions, with steady increases over the next 20 years assuming the existing sea level rise rate, because the tidal prism will increase over time.

Habitat – Habitat will correspondingly shift in vertical and horizontal distribution over the 20-year future as sea level rises. Over time, there will be a steady increase in subtidal area and mudflat habitat, at the expense of vegetated marsh. Remaining vegetated marsh habitat will decline in quality as the inundation frequency is increased and root zones have less ability to drain. Also, existing erosion will continue into the future and may accelerate as plant root strength decreases from over-inundation. The existing 17 acres of vegetated marsh may completely be eliminated under this scenario.

Water Quality – Water quality may actually improve with larger tidal prism and total storage volume under the No Project Alternative. Increased depth of the marsh water column may serve to maintain higher dissolved oxygen levels. Recent research by MBARI indicates that low dissolved oxygen levels resulting from invertebrate activity correlate with shallow water conditions in tidal water bodies (B. Largay, Personal Communication, 2008). The Parsons Complex is presently relatively shallow and may presently lose oxygen from the water column quicker than what would occur if water depths increase. Tidal flushing may decrease due to a larger volume of water stored in the Complex which needs to be circulated, but tidal discharge though the entrance may increase. Increased tidal discharge during each tide cycle will lead to increased flow velocities, resulting in greater wetland scour and sediment loss.

3.4.3.2. Alternative 1 – Structure Only

The structure of Alternative 1 may have a limited effective lifespan that depends on the actual rate of future sea level rise. The structure can be designed to enable some degree of adaptive management during rising water levels by either closing or reducing openings to culverts for inflow, but that capability may be limited over time and the structure may eventually not function effectively.

Hydrology/Hydraulics – The long-term effect of sea level rise under Alternative 1 would be to elevate tidal elevations within the Parsons Complex relative to the tide gates and culverts. As the structures are designed to function as desired for existing conditions, eventually the tide control structure may perform its intended function less optimally. Flexibility can be incorporated into the structure by adjusting inflow culvert openings or closing some, but the tide range will eventually shift upward.

Inundation Frequencies – Under Alternative 1 vegetated marsh habitat could become inundated more frequently, and therefore convert into mudflat, and mudflat could convert to subtidal habitat. The amount of habitat conversion could be significant for Alternative 1 with 11 inches (0.27 m) of sea level rise because tide control was designed to result in maximum vegetated marsh habitat with a high tide of +2 feet (0.6 m) NAVD. If high tide elevations increase, the amount of vegetated marsh habitat could decrease due to more frequent inundation. Figures in Appendix 3-B show the predicted inundation frequency curves. The curve for Alternative 1 would shift 11 inches (0.27 m) to the right from its present position and habitats would colonize higher elevations. If openings to inflow culverts are reduced in size, the effect of sea level rise would be reduced and the rate decreased, but eventually the effect will occur unless the weir structure is significantly modified.

Tidal Prism – For Alternative 1, rising sea level could force more seawater through the inflow culverts in the structure over each rising tide cycle and cause high tidal elevations to progressively rise if inflow culvert openings were not reduced in size. In contrast, the outflow-only culverts through the structure are large enough to drain the site down to the water level outside of Parsons, so a progressive increase in tidal range and tidal prism could occur over time. Estimating the added new tidal prism under this scenario is difficult and requires additional modeling if this alternative were selected to move forward as the preferred alternative. The tide range could be maintained with modification of the sizes of culvert openings, but the tide range will gradually shift upward and increase the tidal prism as more water occupies the elevation range of the tidal prism.

Flow Velocities – Tidal flow velocities out of the Parsons Complex for Alternative 1 could increase if tidal range and prism increased with sea level rise. Scouring and erosion of the wetland would correspondingly increase. If inflow culvert openings were reduced in size or some were closed, these effects may not occur.

Habitat – The spatial distribution of habitat in Alternative 1 could shift in its vertical and horizontal distribution in response to sea level rise. Over time, subtidal habitat and mudflat could increase in area, and vegetated marsh could decrease in area throughout the Parsons Complex. Similar to the No Project Alternative, remaining vegetated marsh habitat could decline in quality if inundation becomes more frequent. Erosion of the wetland could progressively increase as sea levels rise. These effects may not occur if inflow culvert openings are reduced in size or some were closed and tidal flows managed.

Water Quality – Water quality could improve for Alternative 1 with rising sea level. The progressively increasing tidal range and tidal prism could lead to greater depths in the Complex and less oxygen loss. However, the overall volume of water stored in the Complex increases too and needs to be circulated, so these effects may off-set each other. However, water quality may still be expected to be impaired from existing conditions in the 20 year future.

3.4.3.3. Alternative 2 – Sill With Fill (2A – 2E) and Without Fill (2 Only)

Alternative 2 is assessed for both the conditions of no sediment being added, and of large-scale sediment additions in the future.

Hydrology/Hydraulics – As with the other alternatives, the effect of sea level rise for Alternative 2 would be to elevate the tidal condition so that high tide and low tide are both 11 inches (0.27 m) higher than existing conditions, with the tide range remaining the same. This result applies to both the scenarios of no sediment added under Alternative 2 and large-scale sediment additions under this alternative.

Inundation Frequencies – Assuming no large-scale sediment additions, effects of sea level rise on Alternative 2 will be the same as for existing conditions (the No Project Alternative). As water levels progressively rise in the Complex, habitats will shift in position and elevation. Areas that are high marsh will become mudflat, and areas that are mudflat will become subtidal. High intertidal habitat (vegetated salt marsh) will convert to low intertidal habitat (mudflat). Habitat conversion will be significant with sea level rise and eventually salt marsh will be eliminated.

Assuming large-scale sediment additions, effects of sea level rise would be slower and not as detrimental to salt marsh habitat. High marsh habitat would still convert to low marsh habitat, but the entire site would have been elevated by infilling so these effects would be temporarily postponed. If sediment were continually added to the Complex at the same rate as sea level rise, then habitat areas would remain in their distributions. If sediment additions did not keep pace with sea level rise, then ultimate conversion of high marsh habitat to low marsh habitat will occur but over a longer timeframe than for the scenario with no sediment additions.

Tidal Prism – If no sediment were added to the Parsons Complex under Alternative 2, tidal prism would increase as the tidal range is progressively occupied more and more by water rather than land. Without sediment additions to keep pace with sea level rise, Alternative 2 would evolve equivalent to the No Project Alternative, and the increase in tidal prism would be similar.

If sediment were added to the Complex under Alternative 2, the tidal prism of the restored condition would be less than for existing conditions (or the No Project Alternative). This condition of a reduced tidal prism could be maintained over a period of time that would depend on the rate of sediment addition compared to the rate of sea level rise. If sediment additions kept pace with sea level rise, the tidal prism for Alternative 2 could be maintained. If the rate of sediment addition was less than sea level rise, then the tidal prism would increase over time.

Flow Velocities – Assuming no sediment additions, tidal flow velocities at the Parsons main entrance channel would increase from existing conditions as tidal prism increases. Increased tidal flow velocities would lead to increased erosion and loss of marsh.

With sediment additions occurring, tidal flow velocities would be maintained to values similar to the restored condition for some period of time, but they would eventually increase to equal those of existing (No Project Alternative) conditions in the future if sediment additions did not keep pace with sea level rise. If sediment additions kept pace with sea level rise, then flow velocities would be maintained.

Habitat – If no sediment additions occur for Alternative 2, habitat would shift in vertical and horizontal distribution over the 20-year future corresponding to effects of sea level rise. Low marsh and subtidal area would steadily increase, and high marsh would decrease. Any remnant vegetated marsh habitat would decline in quality from increased inundation frequency. Erosion would continue into the future and may accelerate.

If large-scale sediment additions occur for Alternative 2, habitat evolution will be more gradual, and less conversion of high marsh to low marsh and subtidal area would occur over 20 years. However, unless sediment infill keeps pace with sea level rise, ultimately the site will experience large-scale habitat conversion and would ultimately become subtidal and mudflat habitat.

Water Quality – If sediment additions do not occur for Alternative 2, water quality may improve from larger storage volume within the Parsons Complex to provide dilution, and from a deeper water column to retard heating and offset oxygen depletion. However, the residence time may increase due to increased storage volume and off-set this effect. Increased tidal discharge would lead to increased flow velocities, resulting in greater wetland scour and sediment loss.

If large-scale sediment additions occur for Alternative 2, water quality will not appreciably change from that predicted for Alternative 2 with rising sea level. Tidal flushing and residence times should remain improved over existing conditions

3.4.3.4. Alternative 3 – Internal Dikes and All Subalternatives (Assumes Filling for 3A – 3E, and Moderate Tidal Muting of Option 3).

The main (central) area of the Parsons Complex that is not diked will experience conditions similar to the No Project Alternative under Alternative 3. Areas that are diked and muted (6th Finger, Five Fingers, and the Rookery) may experience conditions similar to Alternative 1. South Marsh would be diked and filled, but not muted and may respond similar to Alternative 2 with sediment additions. Internal muting structures of Alternative 3 may have a limited effective lifespan that depends on the rate of sea level rise, unless inflow culvert openings are reduced in size or some were closed to control tides. Option (5), no muting, is not specifically addressed but conditions under sea level rise will be similar to those under Alternative 2 with fill.

Hydrology/Hydraulics – For the main area of the Parsons Complex under Alternative 3, sea level rise would elevate all tidal high and low elevations (the tide range) over time by approximately 11 inches (0.27 m). Tide ranges should remain as they presently exist under this option.

For the muted areas of the Parsons Complex under Alternative 3 the long-term effect of sea level rise could be to raise tidal elevations relative to the tide gates and culverts. The structures would be designed to function for conditions at the time of construction, so shifts in high water level would cause the tide control structure to not perform as desired over the long-term. Flexibility could be incorporated into the structures by reducing the size of the culvert openings or closing one or more inflow culverts to control tides in the future. Tide range can be maintained, but it will shift upward over time under this scenario.

For the areas of the Parsons Complex that are infilled but not muted under Alternative 3, rising sea level would result in a vertical shift of the tidal range upward by 11 inches. Tide ranges should remain as they presently exist under this scenario.

Inundation Frequencies – For the main area of the Parsons Complex under Alternative 3, vertical positions of habitats will correspondingly shift upward as water levels progressively rise in the Complex. High marsh will become low marsh, and low marsh will become subtidal. The amount of habitat conversion will be significant.

For the muted areas of the Parsons Complex under Alternative 3, habitat distribution could change if tide control is not modified. In this instance, vegetated marsh habitat would become inundated more frequently and therefore convert into mudflat, and low mudflat areas would convert to subtidal habitat. The amount of habitat conversion could be significant because tide control structures would be designed to result in maximum vegetated marsh habitat with muted high tides. All habitats would shift upward in elevation with the tide range shift of sea level rise.

Areas and distributions would change accordingly. If inflow culvert openings are deduced in size or some were closed, this effect would decrease and the rate of change reduced, but it would eventually occur.

For the areas of the Parsons Complex that are infilled but not muted under Alternative 3, effects of sea level rise would not be as detrimental to salt marsh habitat as for other areas. High marsh habitat would still convert to low marsh habitat over time, but the effects would be slowed. If sediment were continually added at the same pace as sea level rise, then habitat areas would remain in their restored distributions. If sediment additions did not keep pace with sea level rise, then ultimate conversion of high marsh habitat to low marsh habitat will occur but over a longer timeframe than for other scenarios.

Tidal Prism – The tidal prism of the main area of the Parsons Complex under Alternative 3 will increase as the elevation band within the tidal range is progressively occupied more by water rather than wetland sediment, assuming the wetland elevation remains constant over time while sea level rises. The increase in tidal prism for the main area of Parsons that is outside of muted areas is 7.8 million cubic feet (mcf) from 43.3 mcf existing to 51.1 mcf in the future.

For the muted areas of the Parsons Complex under Alternative 3, rising sea level would force more seawater through inflow culverts over each rising tide cycle and cause high tidal elevations to progressively rise. Outflow-only culverts would be numerous enough to drain the sites down to the water level in the main body of Parsons, so the tidal range and contribution of tidal prism from these areas could increase over time. Estimating sea level rise for muted areas is difficult, and requires additional modeling to occur if this alternative were to move forward as the preferred alternative. If culvert openings are reduced in size, tide ranges can be maintained but would eventually shift upward over time.

For the South Marsh area of the Parsons Complex that is infilled but not muted under Alternative 3, the tidal prism contribution of the restored condition would remain less than for unrestored conditions. The reduced tidal prism could be maintained over a period of time that would depend on the rate of sediment addition compared to the rate of sea level rise. If sediment additions kept pace with sea level rise, the existing tidal prism of South Marsh could be maintained. If the rate of sediment addition was less than sea level rise, then the tidal prism of South Marsh would increase over time, and could eventually equal that of the No Project Alternative.

Flow Velocities – Tidal flow velocities in the main entrance channel of the Parsons Complex under Alternative 3 would progressively increase over time with rising sea level from increasing tidal prism. Tidal prism contributions from the main body of the Complex will progressively increase, while the prism contribution from the muted areas may also increase but more slowly, and the prism of infilled areas may also ultimately increase if fills do not keep pace with sea level rise. Increased flow velocities would lead to increased scour and loss of salt marsh habitat.

Habitat – For the main area of the Parsons Complex under Alternative 3, habitat would shift in vertical and horizontal distribution as sea level rises. Over time, there will be a steady increase in subtidal area and mudflat habitat, at the expense of vegetated marsh. Remaining vegetated marsh habitat would decline in quality as the inundation frequency is increased and root zones have less ability to drain.

For the muted areas of the Parsons Complex under Alternative 3 the spatial distribution of habitat would shift in vertical and horizontal distribution in response to sea level rise, but slower than would occur in unmated areas. Over time, subtidal habitat and mudflat would increase in area, and vegetated marsh would decrease in areas throughout the Parsons Complex that are not muted.

For the areas of the Parsons Complex that are infilled but not muted under Alternative 3, habitat evolution will be more gradual and less conversion of high marsh to low marsh and subtidal area will occur over 20 years. However, unless sediment infill keeps pace with sea level rise, ultimately the site would experience large-scale habitat conversion and ultimately become subtidal and mudflat habitat.

Water Quality – For the main area of the Parsons Complex under Alternative 3, water quality may improve with larger tidal prism and total storage volume. Increased depth of the marsh water column may serve to maintain higher dissolved oxygen levels. Any improvements may be offset by a potential tidal flushing decrease due to a larger stored volume of water in the Complex. This larger water volume has to pass through the entrance channel cross-section over each tidal cycle as tidal discharge. Increased tidal discharge during each tide cycle could lead to increased flow velocities, resulting in greater wetland scour and sediment loss.

For the muted areas of the Parsons Complex under Alternative 3, water quality could improve with rising sea level. The progressively increasing tidal range and tidal prism of muted areas would lead to greater depths, and the increased tidal prism may lead to greater circulation. However, water quality would still expected to be impaired from existing conditions in the 20 year future.

For the areas of the Parsons Complex that are infilled but not muted under Alternative 3, water quality will not be different from the main body of the site, and could improve compared to existing conditions.

3.4.4. Habitat Changes

Wetland restoration is being planned to induce changes to habitat. The project goals and objectives are to increase the area and quality of vegetated salt marsh. This section specifies those changes.

3.4.4.1. Habitat Quantity and Areas

Changes to habitat areas will occur with implementation of each alternative except No Project. The design objective was to significantly increase vegetated marsh habitat over existing conditions and decrease mudflat area. Analyses were completed for the three basic alternatives to quantify the changes caused by the major modifications to the Parsons Complex. Analysis is reported for:

- No Project – Existing conditions.
- Alternative 1 – Structure, with all subalternatives of fill to portray the ultimate restoration scenario (1A – 1E).
- Alternative 2 – Sill, with all areas filled to quantify the outcome of the final configuration (2A – 2E).

- Alternative 3 – Internal Dike and Muting, with all subalternatives included and moderate muting (muting scenario 3) assumed as it provides for the largest tidal range of the options, and therefore the least undesirable effects of muting (3A – 3E). The no muting option (5) is not specifically addressed, but habitat conditions for this option will be the same as for incremental fill scenarios under Alternatives 2A-2E.

Table 3-9 shows the changes in habitat area by subarea (6th Finger, Five Fingers, South Marsh, Rookery) and elevation for a time frame of approximately five years after restoration. The summary of changes in habitat areas presented below assumes all sub-areas are either filled or muted and the entire Parsons Complex is restored. Tables 3-10 through 3-12 show changes for each alternative compared to existing conditions.

3.4.4.1.1. No Project

The No Project Alternative leaves existing conditions in place with no change. Existing conditions are characterized by the site consisting of 81% mudflat, 9% subtidal area, and the remainder is a mix of vegetated salt marsh (4%), and transitional and upland (6% combined) habitats. Figure 3-26 shows existing habitat areas.

3.4.4.1.2. Alternative 1 – Structure and All Subalternatives (1A – 1E)

Alternative 1 results in significant conversion of mudflat area to vegetated salt marsh. Approximately 314 acres (127.07 ha) of mudflat is converted to a combination of 110 new acres (44.51 ha) of vegetated salt marsh, 170 new acres (68.79 ha) of transitional habitat area, and 40 acres (16.19 ha) of upland. Approximately 9 acres (3.64 ha) of subtidal are also lost at the expense of mudflat. This alternative increases the percentage of the site occupied by vegetated marsh to 28% and decreases mudflat area to 13%, while increasing upland from 0.2% to 9%. Figure 3-27 shows the habitat plan for Alternative 1.

3.4.4.1.3. Alternative 2 – Sill With Fills (2A – 2E)

Alternative 2 results in significant conversion of mudflat area to vegetated salt marsh. Approximately 250 acres (102.0 ha) of mudflat and 6 acres of subtidal are directly converted to 259 new acres (104.0 ha) of vegetated salt marsh. Other changes include loss of 9 acres (3.64 ha) of subtidal area. Alternative 2 increases the percentage of vegetated marsh on-site to 60% and reduces mudflat on-site to 26%, while keeping all other habitat areas constant. Figure 3-28 shows the habitat plan for Alternative 2.

3.4.4.1.4. Alternative 3 – Internal Dikes and All Subalternatives (3A[3] – 3E[3])

Alternative 3 also results in significant conversion of mudflat area to vegetated salt marsh, but not to the ultimate extent of Alternative 2 because sediment infill is assumed to not occur in the center of the Parsons Complex. Habitat area changes are therefore limited to the fingers and

South Marsh. Approximately 223 acres (90.24 ha) of mudflat is converted to 188 acres (76.0 ha) of vegetated salt marsh, 19 acres (7.69 ha) of subtidal, and new area of upland. Alternative 3 increases the percentage of vegetated marsh on-site to 23% and reduces mudflat on-site to 57%. Figure 3-29 shows the habitat plan for Alternative 3.

3.4.4.2. Habitat Quality

3.4.4.2.1. No Project

Under the No Project Alternative, the Parsons Complex would continue to have a large amount of relatively high quality subtidal and intertidal mudflat habitat and a minimal amount of salt marsh. The subtidal and intertidal habitats would continue to be used by harbor seals, a variety of water-associated birds, and a variety of fishes including sharks and rays.

Within 20 years, however, continued erosion under the No Project condition would be expected to result in a continuing loss of salt marsh and degradation of the quality of the mudflat and tidal channel habitats. Erosion within the main Elkhorn Slough channel and tidal creeks leading directly off the main channel has resulted in a widening and deepening of these channels and a coarsening of sediment. This erosion has resulted in a decrease in invertebrate diversity and a loss of nursery function. Erosion of the tidal creeks also apparently has resulted in a change in the fish assemblage from an estuarine community to an assemblage dominated by marine species (Yoklavich et al., 2002). The lower prey abundance in the channels, particularly of clams, may have resulted in a decrease in the use of Elkhorn Slough by sea otters (Kieckhefer et al., 2004).

The Parsons Complex now provides some of the functions (such as leopard shark nursery) previously provided by the main tidal creeks. However, the trends of loss of function seen in the main Elkhorn Slough channel and tidal creeks would be expected to occur within the Parsons Complex as erosion continues. It would be expected that continued erosion within the Parsons Complex would lead to a widening and deepening of the channels. As the channels widen and deepen and their sediments become coarser, they would be expected to support fewer invertebrates, particularly clams and they may lose their value as foraging and nursery areas. In addition, mudflat will be lost to continued expansion of the channels.

3.4.4.2.1. Alternative 1 – Structure and All Subalternatives (1A – 1E)

The conversion of mudflat to marsh habitat by the muting of the tides would be beneficial because it would increase the diversity of the system, help to reduce continued degradation of habitat by erosion, and restore salt marsh functions to the Parsons Complex ecosystem. Colonization of currently unvegetated intertidal areas by pickleweed and other marsh species would be expected to begin shortly after project construction and probably will have reached a stable level by Year 5. The basic habitat mix shown in Figure 3-27 would not be expected to change substantially by Year 20. Over time, however, with sea level rise, salt marsh quality and quantity would decrease and subtidal and intertidal habitat would increase.

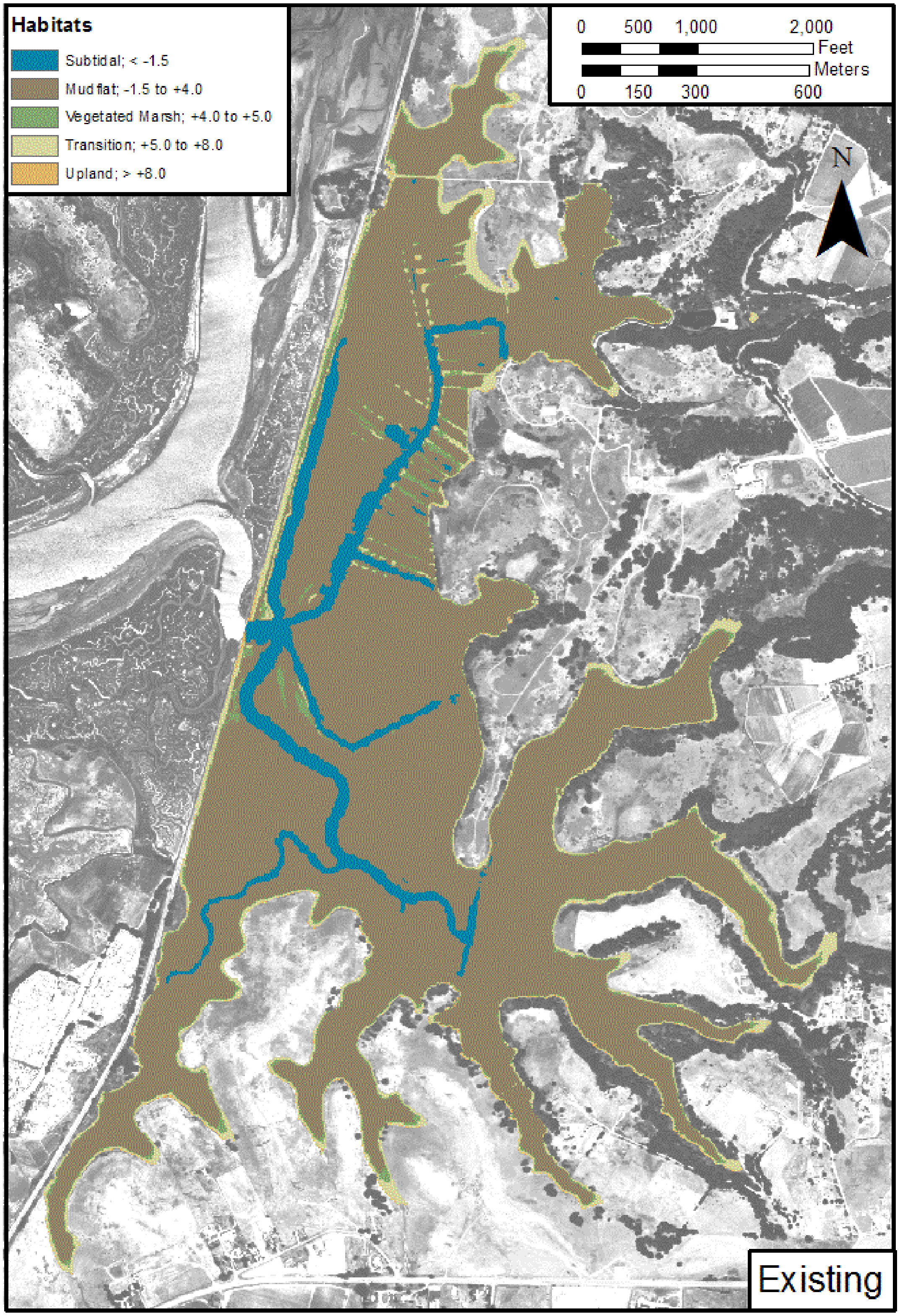


Figure 3-26 - Habitat Areas for the No Project Alternative (Existing Conditions)

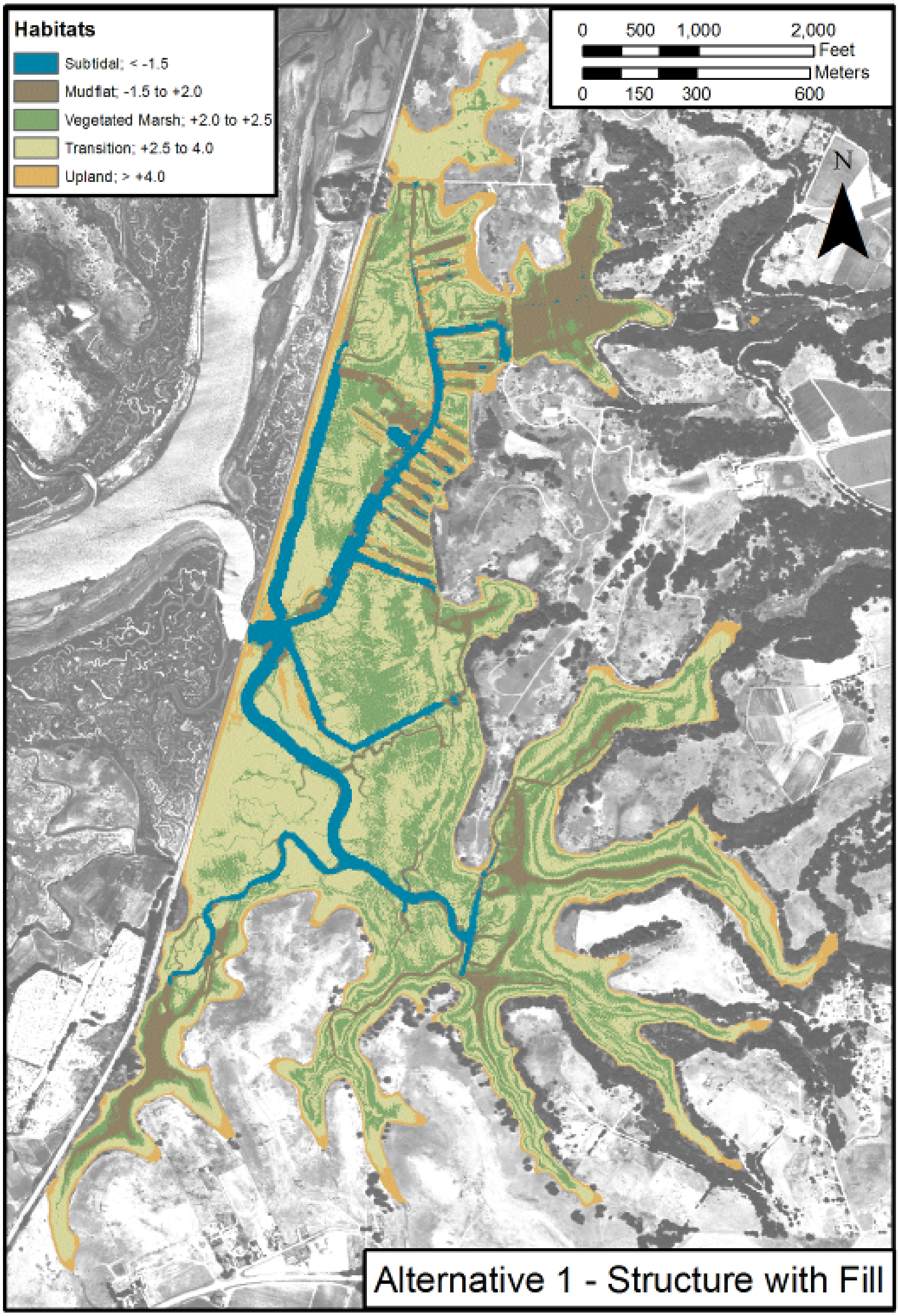


Figure 3-27 - Habitat Area Distributions for Alternative 1, All Subalternatives with Fill (1A – 1E)

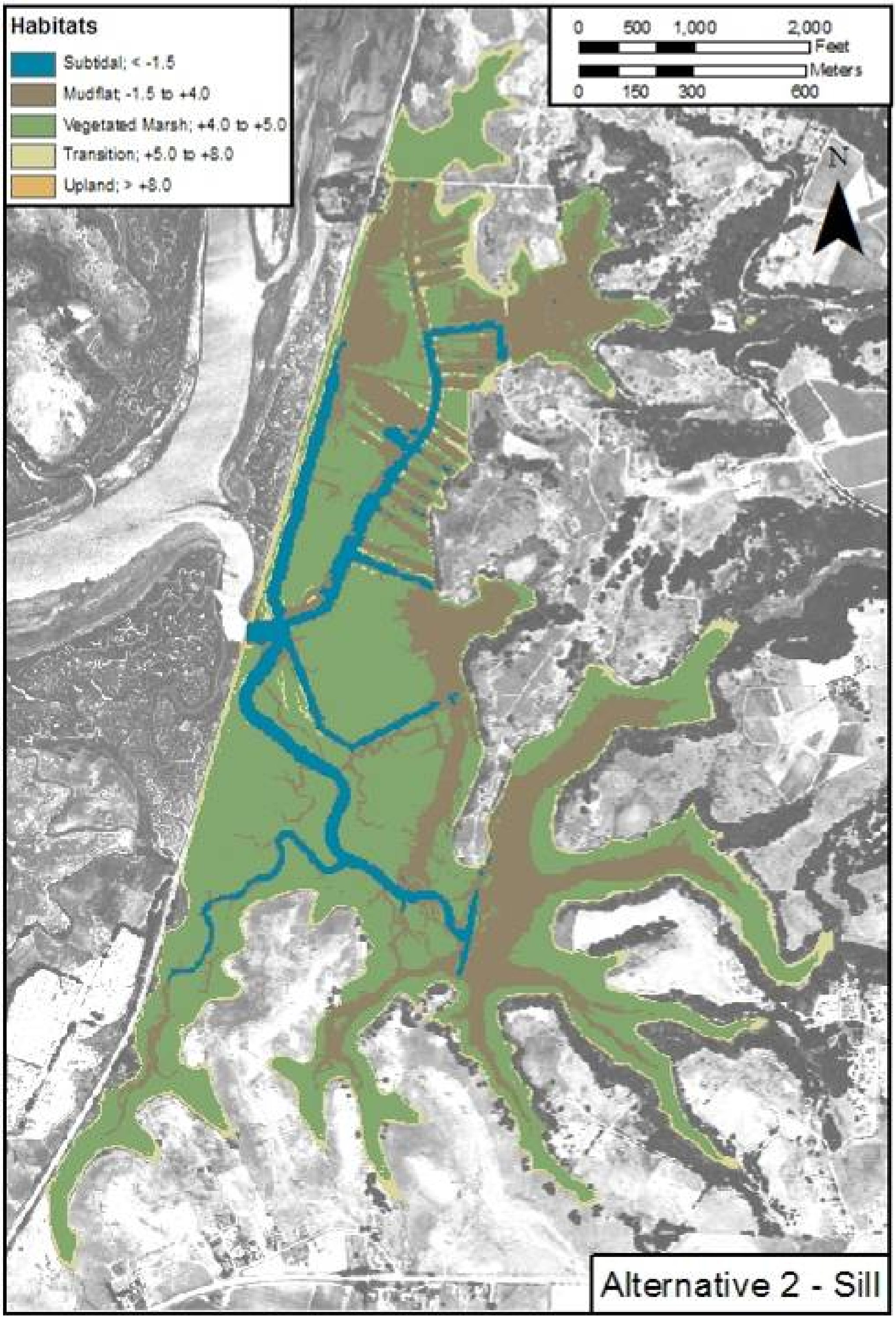


Figure 3-28 - Habitat Area Distributions for Alternative 2, with Fill (2A – 2E)

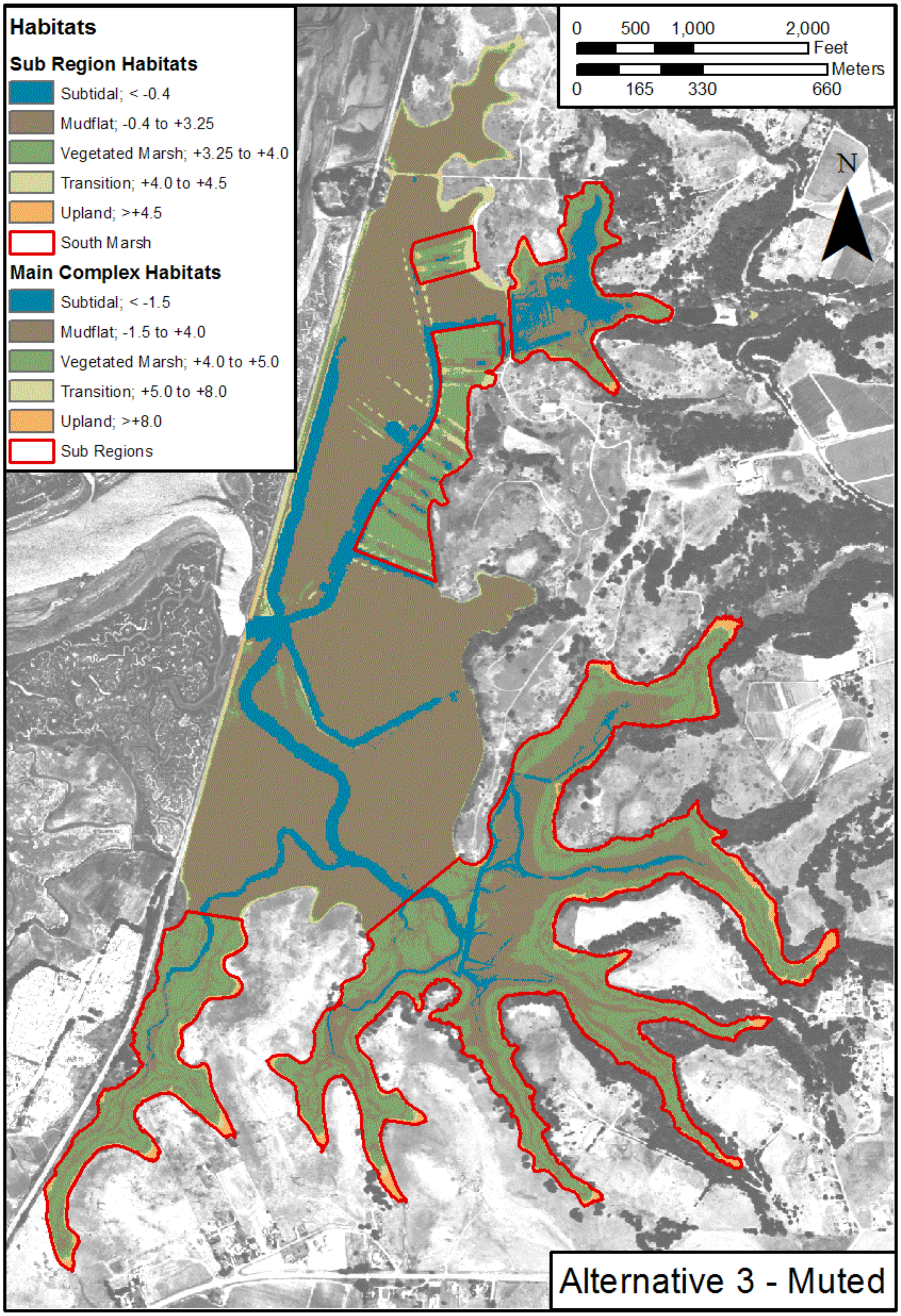


Figure 3-29 - Habitat Area Distributions for Alternative 3, All Subalternatives with Fill, Muting Option 3 (3A[3] – 3E[3])

Table 3-9 – Habitat Areas for Each Alternative

Alternate	Sub Alternate	Habitat Range and Acreage [ft-NAVD] [acres]					
		Subtidal	Mudflat	Vegetated Marsh	Transition	Upland	Total
No Project (Existing Conditions)		< -1.5 **34**	-1.5 to +4.0 **383**	+4.0 to +5.0 **17**	+5.0 to +8.0 **25**	> +8.0 **1**	**460**
1 - Structure	6th Finger	< -1.5 **1**	-1.5 to +2.0 **8**	+2.0 to +2.5 **6**	+2.5 to +4.0 **13**	> +4.0 **5**	**33**
	5 Fingers	< -1.5 **2**	-1.5 to +2.0 **84**	+2.0 to +2.5 **17**	+2.5 to +4.0 **22**	> +4.0 **13**	**139**
	South Marsh	< -1.5 **2**	-1.5 to +2.0 **15**	+2.0 to +2.5 **2**	+2.5 to +4.0 **3**	> +4.0 **5**	**27**
	Rookery	< -1.5 **0**	-1.5 to +2.0 **20**	+2.0 to +2.5 **1**	+2.5 to +4.0 **2**	> +4.0 **2**	**24**
	All Other Regions	< -1.5 **30**	-1.5 to +2.0 **94**	+2.0 to +2.5 **29**	+2.5 to +4.0 **67**	> +4.0 **18**	**237**
	Subtotal	**34**	**220**	**55**	**108**	**42**	**460**
1 - Structure w/ Fill (1A - 1E)	6th Finger	< -1.5 **1**	-1.5 to +2.0 **8**	+2.0 to +2.5 **6**	+2.5 to +4.0 **13**	> +4.0 **5**	**33**
	5 Fingers	< -1.5 **2**	-1.5 to +2.0 **15**	+2.0 to +2.5 **50**	+2.5 to +4.0 **59**	> +4.0 **13**	**139**
	South Marsh	< -1.5 **2**	-1.5 to +2.0 **7**	+2.0 to +2.5 **6**	+2.5 to +4.0 **8**	> +4.0 **5**	**27**
	Rookery	< -1.5 **0**	-1.5 to +2.0 **14**	+2.0 to +2.5 **4**	+2.5 to +4.0 **4**	> +4.0 **2**	**24**
	All Other Regions	< -1.5 **29**	-1.5 to +2.0 **15**	+2.0 to +2.5 **61**	+2.5 to +4.0 **113**	> +4.0 **18**	**237**
	Subtotal	**34**	**60**	**127**	**197**	**42**	**460**
2 - Sill (2A - 2E)	6th Finger	< -1.5 **1**	-1.5 to +4.0 **2**	+4.0 to +5.0 **27**	+5.0 to +8.0 **3**	> +8.0 **0**	**33**
	5 Fingers	< -1.5 **2**	-1.5 to +4.0 **43**	+4.0 to +5.0 **85**	+5.0 to +8.0 **9**	> +8.0 **0**	**139**
	South Marsh	< -1.5 **2**	-1.5 to +4.0 **11**	+4.0 to +5.0 **11**	+5.0 to +8.0 **3**	> +8.0 **0**	**27**
	Rookery	< -1.5 **0**	-1.5 to +4.0 **15**	+4.0 to +5.0 **8**	+5.0 to +8.0 **1**	> +8.0 **0**	**24**
	All Other Regions	< -1.5 **29**	-1.5 to +4.0 **50**	+4.0 to +5.0 **145**	+5.0 to +8.0 **13**	> +8.0 **1**	**237**
	Subtotal	**34**	**121**	**276**	**28**	**1**	**460**
	No Fill	< -1.5 **34**	-1.5 to +4.0 **383**	+4.0 to +5.0 **17**	+5.0 to +8.0 **25**	> +8.0 **1**	**460**

Table 3-9 - Habitat Areas for Each Alternative *(cont.)*

Alternate	Sub Alternate	Habitat Range and Acreage [ft-NAVD] [acres]					
		Subtidal	Mudflat	Vegetated Marsh	Transition	Upland	Total
3 - Mute	6th Finger	< -0.4 **1**	-0.4 to +3.25 **7**	+3.25 to +4.0 **21**	+4.0 to +4.5 **1**	> +4.5 **3**	**33**
	5 Fingers	< -0.4 **9**	-0.4 to +3.25 **54**	+3.25 to +4.0 **63**	+4.0 to +4.5 **3**	> +4.5 **10**	**139**
	South Marsh	< -0.4 **6**	-0.4 to +3.25 **8**	+3.25 to +4.0 **8**	+4.0 to +4.5 **1**	> +4.5 **4**	**27**
	Rookery	< -0.4 **9**	-0.4 to +3.25 **8**	+3.25 to +4.0 **6**	+4.0 to +4.5 **0**	> +4.5 **1**	**24**
	All Other Regions	< -1.5 **30**	-1.5 to +4.0 **187**	+4.0 to +5.0 **9**	+5.0 to +8.0 **11**	> +8.0 **1**	**237**
	Subtotal	**54**	**264**	**106**	**16**	**20**	**460**
3 - Mute w/ Fill [3A(3) - 3E(3)]	6th Finger	< -0.4 **1**	-0.4 to +3.25 **7**	+3.25 to +4.0 **21**	+4.0 to +4.5 **1**	> +4.5 **3**	**33**
	5 Fingers	< -0.4 **9**	-0.4 to +3.25 **54**	+3.25 to +4.0 **63**	+4.0 to +4.5 **3**	> +4.5 **10**	**139**
	South Marsh	< -1.5 **2**	-1.5 to +4.0 **7**	+4.0 to +5.0 **16**	+5.0 to +8.0 **2**	> +8.0 **0**	**27**
	Rookery	< -0.4 **9**	-0.4 to +3.25 **8**	+3.25 to +4.0 **6**	+4.0 to +4.5 **0**	> +4.5 **1**	**24**
	All Other Regions	< -1.5 **30**	-1.5 to +4.0 **187**	+4.0 to +5.0 **9**	+5.0 to +8.0 **11**	> +8.0 **1**	**237**
	Subtotal	**50**	**263**	**114**	**17**	**16**	**460**

Table 3-10 – Habitat Areas for Alternative 1 (1A – 1E) with Fill Compared to Existing Conditions

HABITAT TYPE	ALTERNATIVE 1 WITH FILL AREA (ACRES)	EXISTING - NO PROJECT AREA (ACRES)	DIFFERENCE FROM EXISTING (ACRES)
Subtidal	34	43	-9
Mudflat	60	374	-314
Vegetated Marsh	127	17	110
Transitional	197	27	170
Upland	42	2	40
Total	460	463	-3

Table 3-11 – Habitat Areas for Alternative 2 (2A – 2E) with Fill Compared to Existing Conditions

HABITAT TYPE	ALTERNATIVE 2 AREA (ACRES)	EXISTING - NO PROJECT AREA (ACRES)	DIFFERENCE FROM EXISTING (ACRES)
Subtidal	34	43	-9
Mudflat	121	374	-253
Vegetated Marsh	276	17	259
Transitional	28	27	1
Upland	1	1	0
Total	460	463	-3

Table 3-12 – Habitat Areas for Alternative 3 (3A[3] – 3E[3]) with Fill Compared to Existing Conditions

HABITAT TYPE	ALTERNATIVE 3 WITH FILL AREA (ACRES)	EXISTING - NO PROJECT AREA (ACRES)	DIFFERENCE FROM EXISTING (ACRES)
Subtidal	54	43	11
Mudflat	264	374	-110
Vegetated Marsh	106	17	89
Transitional	16	27	-11
Upland	20	1	19
Total	460	463	-3

With the muting of the tides under Alternative 1, mudflat habitat would be reduced. Therefore, there would be a reduction in area for mudflat invertebrates, fishes including sharks and rays that use mudflats for foraging during high tides, shorebirds that forage on mudflats, and harbor seals that haul out on mudflats. In addition, seabirds that forage in intertidal areas when the tide is high would lose foraging habitat.

Under Alternative 1, Whistlestop Lagoon would convert from mudflat to vegetated salt marsh. Therefore, an area that is currently highly used by otters would be converted to a habitat that otters would not use. The mudflat area near the UPRR Bridge currently used as a haul out area by harbor seals would be converted to salt marsh and probably would be at too high an elevation to be used by harbor seals for hauling out.

Muting of the tides would be expected to cause some changes in community composition. For example, full tidal exchange appears to favor native oysters, commercially valuable flatfish, migratory shorebirds and overall biodiversity (Ritter et al 2008). These biological values would be expected to decrease under Alternative 1. In addition, the fat innkeeper worm, *Urechis*, appears to only occur in full tidal areas. Therefore, muting of the tides under Alternative 1, may cause this species, a target prey item of sharks and rays, to be lost from the Parsons Complex. Whistlestop Lagoon currently supports several species of large clams as well as oysters. Some of the clam species (*Saxidomus natalli, Venerupis japonica, Irus lamellifer*) were found in recent surveys in Whistlestop Lagoon but not in other areas. The intertidal habitat in Whistlestop Lagoon would be lost for these species because muting of the tides at the UPRR Bridge would eliminate mudflat habitat at Whistlestop and converted it to salt marsh. It is not known whether the muted mudflat areas that would be present in the Parsons Complex after the implementation of Alternative 1 would support these clam species or if they would be lost to the Parsons Complex.

Muting of the tides appears to result in lower salt marsh diversity compared to fully tidal sites, as presented in M&N 2007. Therefore, while total salt marsh acreage may increase, the salt marsh might be expected to have lower species richness than in the full tidal system. The ecotone between wetlands and uplands is narrower in muted tidal systems, such as under Alternative 1. Ecotones, the transitional areas between adjacent ecological systems, frequently host high biodiversity because they contain characteristics of both adjacent systems as well as distinctive microhabitats. They frequently intensify flows of water and nutrients, and facilitate movement of organisms. Ecotones tend to be narrow zones between two larger ecosystems and so any loss of area could result in significant changes to biodiversity. In addition to whole scale loss of habitat through narrowing or loss of vegetation, alterations could lead to changes in species assemblages (Wasson and Woolfolk, 2007). In addition, this alternative would result in a net loss of tidal habitat.

The residence time of water in the overall Parsons Complex would increase from 3.2 days to 3.9 days. Although this increase in residence time would not result in a year round decrease in water quality, it could result in an increase in periods of low dissolved oxygen levels and elevated temperatures during the summer months (see Section 3.2). Decreased use of the Parsons Complex by leopard sharks during the late summer is thought to be a result of these decreased oxygen and elevated temperature conditions (Carlisle, 2006). Therefore, in addition to a loss in the quantity of mudflat habitat used by sharks and rays, the quality of the remaining mudflat and subtidal habitat for these species would be lower than under the existing conditions. Frequent or extended periods of decreased oxygen and higher temperatures could be stressful to other fish and invertebrate species, although estuarine fishes and invertebrates tend to be tolerant of fluctuating environmental conditions. Temperatures exceeding 25 degrees C (80 degrees F), which have been measured under existing conditions, approach levels that are at the upper end of the tolerance range even for estuarine fishes (Emmett et al 1991).

Incremental fill in the Five Fingers and/or South Marsh would increase the quantity of salt marsh habitat. The placement of new sediment might encourage the colonization of non-native invertebrates which then may threaten native invertebrates.

Conversion of most of the Five Fingers from mudflat habitat to salt marsh by the placement of fill would further reduce the mudflat area that is used by sharks and rays. Five Fingers is an area that has been found to be highly used by leopard sharks under the existing condition (Carlisle, 2006). Although channels would still exist in the Five Fingers, almost all the mudflat would become salt marsh. In addition the presence of culverts and possibly tide gates would reduce access to these areas by sharks and rays.

Filling the area between the islands in South Marsh also would remove areas used by leopard sharks. Fill between the islands in South Marsh would increase roosting habitat for a variety of birds but would also reduce the foraging area of seabirds and shorebirds. Muting of tides by culverts or tide gates would increase the residence time of water and likely would result in more frequent and more extended periods of low dissolved oxygen and elevated temperatures in the summer and early fall months. Therefore, the habitat quality for fishes and invertebrates in the South Marsh would be expected to be low and stressful for aquatic organisms during summer and early fall.

3.4.4.2.2. Alternative 2 – Sill With Fills (2A – 2E)

The conversion of mudflat to marsh habitat by the placement of sediment would be beneficial because it would increase the diversity of the system, help to reduce continued degradation of habitat by erosion, and restore salt marsh functions to the Parsons Complex ecosystem. However, mudflat habitat would be lost. Therefore, there would be a reduction in area for mudflat invertebrates, fishes including sharks and rays that use mudflats for foraging during high tides, shorebirds that forage on mudflats, and harbor seals that haul out on mudflats. Colonization of currently unvegetated intertidal areas by pickleweed and other marsh species would be expected to begin shortly after project construction and probably will have reached a stable level by Year 5. The distribution and quality of habitats would not be expected to change substantially under Alternative 2 between Year 5 and Year 20. Over time, however, with sea level rise, salt marsh quality and quantity would decrease and subtidal and intertidal habitat would increase, unless fills continue and kept pace with sea level rise.

The sill will be a barrier for many larger organisms such as sharks and seals. The potential for the sill to be a barrier to the passage of fish and wildlife is discussed in Section 3.8 Preliminary Environmental Review.

The quality of mudflat habitat in the Parsons Complex would continue to be high and similar to the existing condition. The sill would prevent continued erosion of the channels, which under the No Project Alternative and Alternative 3 would continue to widen and deepen.

The construction of a sill at the entrance to the Parsons Complex would not mute the tides in the central portions of the Complex. If the fill were not contained, sediment would be expected to spread so that at ultimate build out, elevations would be such that salt marsh would develop in the 6th Finger, in most of the central Parsons Complex, much of South Marsh and along the edges of the Five Fingers. This salt marsh would be exposed to a full tidal range and would be expected to contain the diversity found in fully tidal salt marsh areas in Elkhorn Slough. If fill were placed behind a dike but with a full tidal connection provided as an open channel or large low culverts, then the new marsh areas would not be muted and salt marsh diversity would be expected to be similar to what it would in a full tidal system.

Under Alternative 2, the residence time of water in the central Parsons Complex would be the same as under existing conditions or possibly even less (Section 3.2). If fill were not contained, the residence time of water in the Five Fingers would also be similar to the existing conditions. It would be expected that there may be some incidences of low dissolved oxygen and elevated temperatures in late summer as occurs under existing conditions but water quality would not be worse. Therefore, the habitat quality in the subtidal channels and mudflats for invertebrates and fishes, including sharks and rays, would be at least as good as under the existing condition.

The placement of new sediment might encourage the colonization of non-native species which then may prevent native species from becoming established.

3.4.4.2.3. Alternative 3 – Internal Dikes and All Subalternatives (3A[3] – 3E[3])

A tidal muting option is addressed herein to demonstrate a conservative scenario specifically addressed, but its conditions are covered under Alternative 2. At 5 to 20 years after restoration, the habitat quality in the Five Fingers, 6th Finger, South Marsh, and Rookery of the Parsons Complex under this alternative would be somewhat similar to Alternative 2. The habitat in the central portions of the Parsons Complex would not be muted and the quality of mudflat and subtidal channels would be good and similar to the existing condition. However, without the sill, erosion in the main portions of the Parsons Complex would continue and channels would widen and deepen. Over time (probably by the 20 year mark), the channels would resemble the main channel of Elkhorn Slough and, like tidal channels elsewhere in Elkhorn Slough, might lose their function as nursery areas for sharks and rays. The small amount of salt marsh in the main portions of the Parsons Complex (i.e. areas that would not be diked and filled) would continue to erode and might be lost within 20 years.

Placement of fill behind dikes in strategic areas would add salt marsh habitat to the system. This salt marsh would add diversity to the habitats in the Parsons Complex and would restore salt marsh functions (such as nutrient production, shelter for a variety of animals and water cleansing) to the system. However, in any of the potential scenarios under Alternative 3, the habitat behind the dike(s) would be muted. Therefore, the salt marsh would be expected to have a lower diversity of vegetation than salt marsh in fully tidal systems and the salt marsh/upland ecotone in these diked areas would be narrower than in fully tidal system. Muting of the tides would increase the residence time of the water behind the diked areas. Although the residence times would not necessarily be expected to be long enough to result in a year-round degradation of water quality (Section 3.2), low dissolved oxygen concentrations and elevated temperatures might occur in these muted areas during the summer. The habitat quality of the remaining channel and mudflat habitats in these diked areas, therefore would be lower than under the existing condition and would create stressful conditions for fishes and aquatic invertebrates in summer and early fall.

If the Five Fingers area were diked and filled, channel and mudflat habitat that is highly used by leopard sharks would be lost. Diking and filling the area between the islands in South Marsh also would remove areas used by leopard sharks. Fill between the islands in South Marsh would increase roosting habitat for a variety of birds but would also reduce the foraging area of seabirds and shorebirds. As the 6th Finger is little utilized by leopard sharks, they would not be affected by filling there.

3.4.5. Potential Impacts to the Railroad Levee and Related Structures

Restoration alternatives are evaluated below for the potential to impact the railroad levee and related structures. The UPRR has expressed concern about their levee being overtopped during maximum spring tides while water levels in Parsons are lower than in Elkhorn, thus leading to cascading flow across the railroad bedding. Any option that causes this condition would be considered problematic.

3.4.5.1. No Project

The No Project Alternative will not change any condition along the railroad levee and related structures, such as the UPRR bridge. Existing conditions will remain, and the railroad's operation will remain unaffected by restoration as none will occur.

3.4.5.2. Alternative 1 – Structure and All Subalternatives (1A – 1E)

Alternative 1 proposes a structure attached to the UPRR levee to control water levels in the wetland. This concept requires UPRR approval. It would be designed to allow higher spring high tides to reach maximum elevations on both sides of the UPRR levee and thereby maintain hydrostatic pressure on both sides of the railroad line as presently occurs. As such, theoretically it should cause no impact or effect to the UPRR levee or related structures.

The main caveat of this conclusion is that a structure which performs to both significantly mute the tides and still allow high water levels to be reached along the rail line will possess gates or openings that allow more water into the wetland under predicted maximum spring tides. This type of variable tide gate operation requires manual management or automation. Either option could potentially experience performance failure. Any concept that fails and does not allow equalization of hydrostatic pressure along both sides of the railroad levee presents the potential for catastrophic levee failure.

3.4.5.3. Alternative 2 – Sill With Fill (2A – 2E)

Alternative 2 proposes a sill across the channel just downstream of the UPRR bridge. The sill would not be attached to the bridge, but would retain sediment on its inboard (Parsons) side in the vicinity of the UPRR bridge. This concept should have a neutral to beneficial effect on the UPRR bridge as increased sedimentation under the structure in the entrance channel should fill existing scour areas, increase protection to the bridge piles, and increase the integrity of the structure. The channel under the bridge has been an eroding feature since about the mid-1940s, and the railroad had to replace the bridge in 2003 due to deterioration and undermining. This project would counter and stop channel scour and bridge undermining.

Also, the sill should not affect the railroad levee as high tides are not muted and water levels are still allowed reach maximum elevations on both sides of the levee into perpetuity. Finally, the sill is not physically attached to the UPRR bridge so direct impacts or effects to any railroad structure would not occur. Placement of fill inside the marsh using a hydraulic discharge line under the bridge and through UPRR property may require permission from the railroad.

3.4.5.4. Alternative 3 – Internal Dikes and All Subalternatives (3A[3] – 3E[3])

Alternative 3 only proposes restoration actions within Parsons, inboard of the UPRR levee, and structures and will, therefore have no direct effect on UPRR property. An indirect benefit will occur to the UPRR bridge as tidal prism will be reduced by this alternative. Reduced tidal prism will reduce scouring of the channel and possible undermining of the bridge. As such, bridge stability should improve from this restoration option. Conversely, this alternative does not address the fundamental problem of erosion and loss of sediment from the main area of the Parsons Complex, so entrance channel scour and bridge undermining could still occur. The no muting option of Alternative 3 will also result in no adverse effect to UPRR infrastructure.

3.4.6. Maintenance Requirements and Costs

Long-term maintenance is typically required at every wetland restoration project site. Certain restoration actions lead to more maintenance than others. A brief discussion of probable maintenance requirements is provided for each alternative. The various structural components that will require maintenance for all of the alternatives and approximate maintenance costs include those listed in Table 3-11.

3.4.6.1. Alternative 1 – Structure and All Subalternatives (1A – 1E)

Alternative 1 will require maintenance due to the hardware associated with the structure. The flap gates and culverts will require periodic repair, and possible replacement, and potential cleaning. Manual gates tend to stick and need loosening, and automatic gates may experience problems with the power supply, connections, and with moving parts. The degree of maintenance can be minimized by using high-quality stainless steel and other non-corrosive materials, but general observations at other sites (e.g., Bolsa Chica) indicate that maintenance tends to increase in direct relation to the number of structural components added to a system.

3.4.6.2. Alternative 2 – Sill With Fill (2A – 2E)

Alternative 2 will also require maintenance, as the sill may periodically need repair if it is scoured or incrementally damaged over time by currents or channel scour. Rock can be added to the structure to maintain its integrity and compensate for any settling.

Table 3-13 – Maintenance Items and Approximate Costs for Restoration Alternatives

Main Alternative	Entrance Channel Maintenance Items	Subalternative	Internal Slough Maintenance Items	Approximate Annual Maintenance Costs
No Project	None	None	Existing foot bridge at Rookery, dike and culverts at Whistlestop	**Total of less than $25,000**
Alternative 1 (1A – 1E)	-1 structure -9 main flap gates -13 main culverts	1A. 6th Finger 1B. Five Fingers 1C. South Marsh 1D. Rookery	No Changes 1. Internal dike and 3 to 4 culverts (flap gates not assumed) 2. Internal dikes	No Cost at 6th Finger Structure $25,000 – 75,000 Dikes $10,000 - $100,000 Culverts $0-$10,000 Gates - none Dikes $10,000 to $50,000 No Cost at the Rookery **Total $45,000-$235,000**
Alternative 2 (2A – 2E)	-1 sill structure	2A. 6th Finger 2B. Five Fingers 2C. South Marsh 2D. Rookery 2E. All Other Areas	1. Internal dike and possibly 3 to 4 culverts 2. Internal dike, up to 3 to 5 culverts 3. Internal dikes	Sill $5,000-$100,000 Dikes $10,000-$150,000 Culverts $0-$10,000 Dikes $10,000 to $50,000 No Cost at the Rookery No Cost at Other Areas **Total $25,000-$310,000**
Alternative 3 (3A[3] – 3E[3]) *Note:* the no muting option is not specifically addressed, but it would require dikes, and possibly some culverts, but no flap gates.	No major entrance channel maintenance items	3A. 6th Finger 3B. Five Fingers 3C. South Marsh 3D. Rookery	1. Internal dike, 3 to 5 culverts, and 3 to 5 flap gates 2. Internal dike, 8 to 9 culverts and 5 to 7 flap gates 3. Internal dikes 4. Internal dike, 4 to 5 culverts, and 3 to 5 flap gates	Dikes $10,000-$75,000 Culverts $0-$40,000 Gates $10,000-$100,000 Dikes $20,000-$150,000 Culverts $0-$40,000 Gates $20,000-$100,000 Dikes $10,000 to $50,000 Dikes $5,000-$35,000 Culverts $0-$40,000 Gates $10,000-$100,000 **Total $85,000-$730,000**

3.4.6.3. Alternative 3 – Internal Dikes and All Subalternatives (3A[3] – 3E[3])

Alternative 3 would also require maintenance. Four tidal muting options exist with this alternative that would require containment dikes, multiple culverts (potentially up to 8 or 9 for inflow, and up to 5 to 7 flap gates for outflow at the Five Fingers, with fewer at both the 6^{th} Finger and the Rookery). South Marsh would only require dikes and no culverts. Each item would likely require maintenance to some degree, and typically more structural items require more potential maintenance. The no muting option would also require dikes, and possibly culverts, but no flap gates. As such, this option would require the lowest level of maintenance for Alternative 3.

3.4.7. Estimated Construction Costs

Opinions of probable construction costs were estimated for the alternatives and are provided in Appendix C4 12 below shows the total cost for each alternative. Spreadsheets in Appendix 3-C show the itemized breakdown of the cost for each option. Costs for all alternatives include allowances for design, engineering, environmental review, permitting, and construction support and management (estimated as a percentage of the total project construction costs) as shown in the Appendix.

The greatest cost components are sediment additions, and the associated need for containment diking and culverts. These costs assume complete filling of certain areas, and costs would be lower if only one finger, or a portion of a finger were filled at a time.

Monitoring will also be required and will likely be fairly intensive for any alternative, considering the extent of habitat change that will occur for any action. Monitoring actions would address tidal elevations, water quality, and habitat evolution.

For comparison evaluation of alternatives, monitoring costs may be highest for Alternative 1 that proposes tidal muting over the entire site, particularly with potential water quality issues in the Five Fingers. The cost for monitoring of that alternative may reach up to $50,000 or more annually. Monitoring costs may be less for Alternative 2 because fill may have to be added incrementally. Monitoring costs for Alternative 3 may also be lower than Alternative 1 because smaller areas of the Complex are physically changed.

3.4.7.1. Costs of Fill Addition

The costs to place fill by various methods within the Parsons Complex is critical to the preferred restoration alternatives, as this item is a significant component of the total cost of restoration. Moffatt & Nichol refined the cost estimates for sediment additions to help determine whether costs can be reduced from estimates in the Draft Analysis of Restoration Alternatives Report

(Moffatt & Nichol 2008). This section of the report provides further refinement of costs to fill the site.

Table 3-14 – Estimated Probable Construction Costs of Restoration Alternatives

MARSH		CONSTRUCTION COST ESTIMATES (Rounded, in Millions)
Alternative 1	Alternative 1 – Structure Only	$5.4
	Alternative 1A	N/A
	Subalternative 1B – Fill Five Fingers	$2.8
	Subalternative 1C – Fill South Marsh	$10.1
	Subalternative 1D – Fill Rookery	$0.5
	Subalternative 1E – Structure and All Other Areas	$2.7
	Alternatives 1A – 1E	$25.3
Alternative 2	Alternative 2 – Sill Only	$1.9
	Subalternative 2A – Fill 6th Finger	$2.7
	Subalternative 2B – Fill Five Fingers	$11.0
	Subalternative 2C – Fill South Marsh	$11.0
	Subalternative 2D – Fill Rookery	$1.3
	Subalternative 2E – Fill All Other Areas	$11.7
	Subalternative 2 – Sill and All Fills	$40.0
Alternative 3	Alternative 3A – Mute and Fill 6th Finger	$3.7
	Alternative 3B – Mute and Fill Five Fingers	$9.8
	Alternative 3C –Fill South Marsh	$12.0
	Alternative 3D – Mute and Fill Rookery	$1.8
	Alternative 3E – Mute and All Fills	$32.0

** Data in the Table for Alternative 2A-D also apply to Alternative 3A-D(5).*

All costs are updated in the subsequent Restoration Plan document.

3.4.7.1.1. Transport of Fill

Transporting fill material can be done effectively by either a slurry discharge line, trucks, or rail. Each option has been presented in the Sediment Additions Report (M&N 2008). The ESNERR prefers the concept of using a slurry line to transport sediment over the long-term to the Parsons Complex due to its reduced environmental impacts as compared to trucking. Also, rail transport would be difficult to implement due to logistical challenges at the wetland drop-off point. Each option is presented below for consideration.

Several possible sources of sediment are presented in the Sediment Additions Report for the Parsons Complex (Moffatt & Nichol 2008). One significant source of sediment exists approximately nine miles northeast of the Parsons Complex at the Graniterock Wilson Quarry site, or referenced as the Quarry in this report. This source is used as a possible example of sediment that could conceivably be pumped as a slurry mixture through a pipeline to the Parsons Complex.

Slurry Discharge Line

Graniterock Wilson Quarry processes construction aggregate material and generates very fine-grained sediment, referred to as "granite dust," as a byproduct of their operation. This granite dust is either beneficially re-used or discarded. The material grain size is 80% silts/clays (finer than sand) with the remainder being the size of fine sand. It is chemically inert and mostly composed of silica. As such, it may require amendments to increase its fertility.

A conceptual layout of a slurry discharge line operation, to convey the material from Graniterock Quarry to the Parsons Complex, is presented with the pipeline located along the railroad right-of-way and is shown in Figure 3-30. The railroad right-of-way presents a relatively smooth and gradual downhill grade from the Quarry to the Parsons Complex over a distance of 13 miles. This route is desirable because no significant topographic barriers exist along the flow path, and the fewest infrastructural obstructions exist to operation, so the slurry can be effectively pumped from the source to its destination. Other routes would include a combination of significant topographic barriers, multiple landowners, and/or various infrastructural constraints to the operation. The profile of the concept slurry discharge line route is shown in Figure 3-31.

Costs to implement this long-term restoration operation are relatively high based on the assumptions used in this analysis (see below). The estimated cost to install this system is between $14 and $22 million, with annual operating costs of between $700,000 and $900,000. Assumptions used in preparing this estimate include:

- The discharge line is composed of an 14-inch diameter High-Density Polyethylene line (HDPE) that is 13 miles long;

- One large pump and three smaller booster pumps are required to propel the slurry mixture through the discharge line;
- Pumps are powered by electricity;
- Additional water is required to be added to the slurry at the Quarry to create the proper water content for efficient pumping, and that water is pumped from one of two sources:
    - Elkhorn Slough through a separate return water line that is the same size and material as the slurry discharge line; or
    - The Pajaro River or a well near the Quarry;
- Railroad right-of-way needs to be obtained to allow the system to be installed and to operate over the long-term (cost unknown and still being researched with the UPRR real estate department, but assumed to be $15 per square foot for a cost of $3 million); and
- Labor and equipment are needed to install and maintain the system and are included in the estimate.

Costs could conceivably be reduced if some assumptions were modified. The two highest cost items for installing the system are those for the discharge line and acquiring the right-of-way. The estimate is conservatively based on assuming that the slurry discharge line and the return water supply line are placed in separate trenches. If the lines can be placed in the same trench that is larger, the cost could be reduced. The highest cost item to operate the system is to power the pumps.

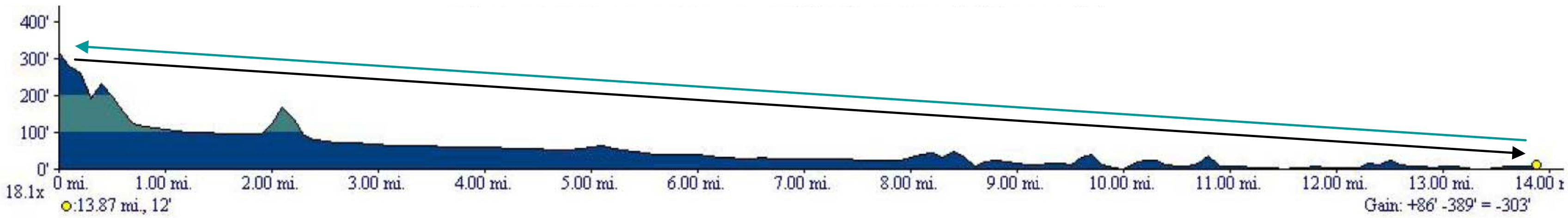
The UPRR indicated reluctance to allowing lines owned by others to be within their right-of-way, so this may pose a significant constraint to this option, although it may not be rendered infeasible. Their requirements of any plastic line within their right-of-way is to be encased in metal or concrete, buried, or located 50 feet from their tracks (McCune, Mark, Personal Communication 2008). The proposed HDPE material of the slurry line would be stronger than plastic, so these restrictions could potentially be re-evaluated (and are still being discussed with the UPRR).

Finally, the need for return water could be reconsidered if sufficient quantities and quality of water were available near the Quarry. The Quarry draws water from a well near the Pajaro River. If water from that River were used as the source of the added water rather than pumping it from Elkhorn, then costs may be reduced. Costs to buy water from the local water authority have to be determined, but if water could be supplied near the quarry, the overall project costs could be reduced to $14 million (B. Largay, Personal Communication). The problem with using freshwater as a return water source is that there is a shortage of this resource and it may not be available in the volumes needed for the slurry system. Two local water districts in the area both indicated they could not provide sufficient water volume to fully supply the system (B. Largay, Personal Communication).

Slurry line in yellow
From Graniterock
To Elkhorn Slough;
Railroad under
Yellow line.

Figure 3-30 – Sediment Slurry Line Concept Plan

Sediment Slurry Line Would Follow The Downhill Grade From Quarry to Marsh



Water Return Line Would Follow Uphill The Grade From Marsh to Quarry

Figure 3-31 – Sediment Slurry Concept Profile

Cost estimates for construction and operation of the slurry system under the two different scenarios of a return water source are shown in 3-B. The slurry line system is likely to be the most environmentally sensitive option compared to other land-based options that are more disturbing to the community and require more energy.

Other Transport Options

Considering the potentially high cost of importing fill via a slurry discharge line from the upstream quarry, the other options of transport by truck, rail, and dredge are also presented as options. Each is addressed further below. Itemized cost estimates for each concept are included in Appendix 3-C.

Trucking

Preliminary estimates provided by Graniterock Wilson Quarry of the cost to transport material by truck show them to be higher than the slurry line option ($55 million), but less expensive options likely exist. Although the ESNERR may not wish to truck all of the material to the site for various reasons, they may want to consider trucking some of the material to optimize the operation. One benefit of using trucks is the fill can be delivered in relatively small increments over time to match available funding, or can be used by donors that may be willing to contribute the sediment free of charge such as from Santa Cruz Harbor (Brian Foss, Personal Communication) and Caltrans. It may be a suitable mode of delivery for short-term, relatively small-scale deliveries in the future to supplement any larger projects done by slurry line or rail.

Material trucked from the Quarry would be much drier than the material that would be slurried, as the Quarry processes their material to the consistency of modeling clay prior to trucking. To pump the material to the precise location at where it is needed at Parsons, it may be necessary create a small "batch plant" somewhere to fluidize the material so it can be pumped as slurry into the marsh. Trucking would impact the community with increased noise, traffic, wear of roads, use of fuel, and decreased highway safety.

Rail

Transport by rail may be a cost-effective option when compared to costs of other options. Preliminary costs are under preparation as of this writing, but are not yet complete and will be provided upon completion. Initial estimates have the cost for a rail operation to be approximately $35 million. Rail would most likely be best suited for large-scale sediment delivery projects. Delivery by rail will entail installing an offloading station where the material can be removed from the rail cars, stockpiled, and possibly fluidized for transport into the Parsons Complex. Another final placement option is use of trucks or earthmovers to carry the material to the marsh and place it at the target locations.

Ocean Dredge Discharge Line

The Sediment Additions Report presented dredging of sediment in the open ocean for placement at Parsons as one source option. If the project were constructed at one time using sediment dredged from the open ocean and discharged through a slurry line to the site, the costs would be $41 million. Dredging would definitely be best suited for one large-scale sediment delivery project due to the very high mobilization cost. Advantages are that sediments pumped into Parsons can be marine muds that may not need substantial (or any) amendment.

3.4.7.1.2. Placement of Fill

This restoration plan emphasizes sediment delivery by a slurry discharge line from the upstream quarry. A distribution network will need to be installed within the Parsons Complex to fill all areas in need of sediment. Two concept slurry line distribution networks are recommended for consideration. The concept systems are intended to show pathways of pipeline extensions from the main 14-inch supply line. Two concepts are offered because this site does not lend itself to one straightforward approach to installing the system due to physical constraints of the wetland.

One approach, shown in Figure 3-32, is to work from the water side (bases) of the fingers at Parsons, and extend a slurry line upstream to the far ends of the fingers and fill by:

- Installing containment berms at the bases of the fingers to be filled;
- Floating the slurry line into the marsh up through the main entrance channel and directing it into the finger(s) to be filled;
- Extending the discharge line to the far end of the finger(s);
- Discharging fill and creating the desired grade;
- Retracting the discharge line by removing a length of line and directing discharge at new target areas for filling; and
- Discharge fill to the new area at the end of the discharge line, and continue this operation until the entire finger is filled.

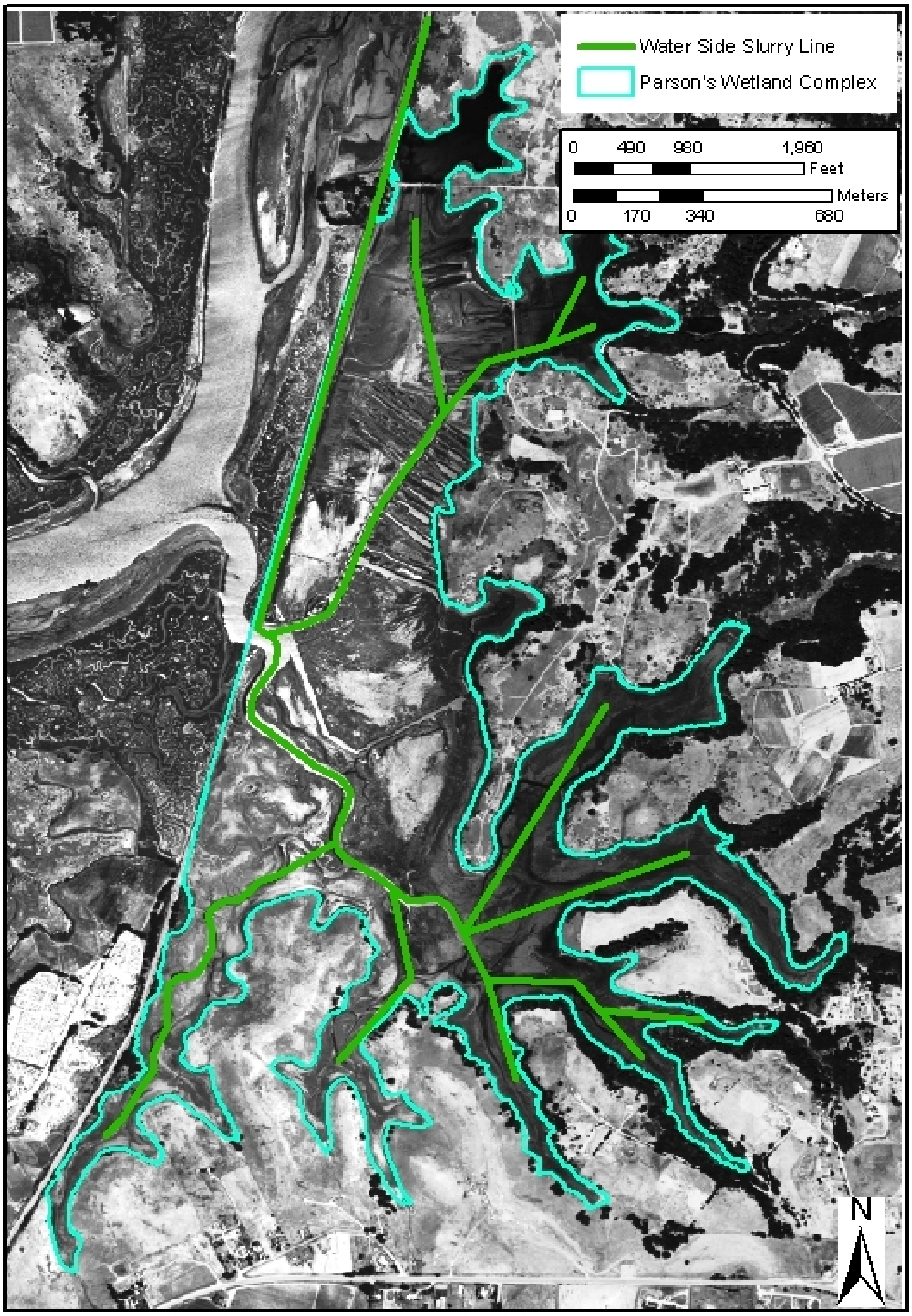


Figure 3-32 – Parsons Slurry Line Distribution on Water

Another approach, shown in Figure 3-33, is to work from the land side of the fingers, and extend a slurry line downstream from the far ends of the fingers toward their bases. Each site would be filled in a similar way as described above, but just reversed as:

- Install containment berms at the bases of the fingers to be filled;
- Lay the slurry line around the marsh perimeter and directing it into the upstream end of the finger to be filled;
- Fill the upstream end of the finger and create the desired grade;
- Extend the discharge line farther downstream into the finger toward the base by adding a length of line;
- Discharge more fill and create the desired grade;
- Extend the discharge line by adding a length of line and directing discharge at new target areas for filling; and
- Discharge fill to the new area at the end of the discharge line, and continue this operation until the entire finger is filled.

The costs of the distribution system are included in the overall estimate of the slurry systems in Appendix 3-B.

3.4.7.1.3. Amendment of Fill Material

Potential soil fill material placed at the Parsons Complex needs to support a broad range of organisms, ranging from phyto- and zooplankton to salt marsh plants to benthic macroinvertebrates. Though the physical and chemical properties of the granite dust have yet to be evaluated thoroughly, initial analyses indicate that the material may require amendment of organic material to make it of sufficient quality to enable and sustain development of a vigorous benthic food chain. The present understanding of the physical and chemical properties of the Quarry fill is summarized below:

<u>Organic Carbon Content</u>

The material likely has low levels of organic carbon and a low cation exchange capacity. Since the Parsons estuary is rich in organic carbon and nitrogen, there is a reasonable expectation that nutrient enrichment of the granite dust would occur over time through deposition and biological incorporation. If enrichment by these processes is insufficient to provide a proper substrate for the invertebrate community, then the expense of organic material enrichment would be justified. An example long-term goal of organic enrichment could be a minimum of 5% organic carbon to a depth of one foot (30 centimeters). This goal requires verification by the Parsons Restoration Team.

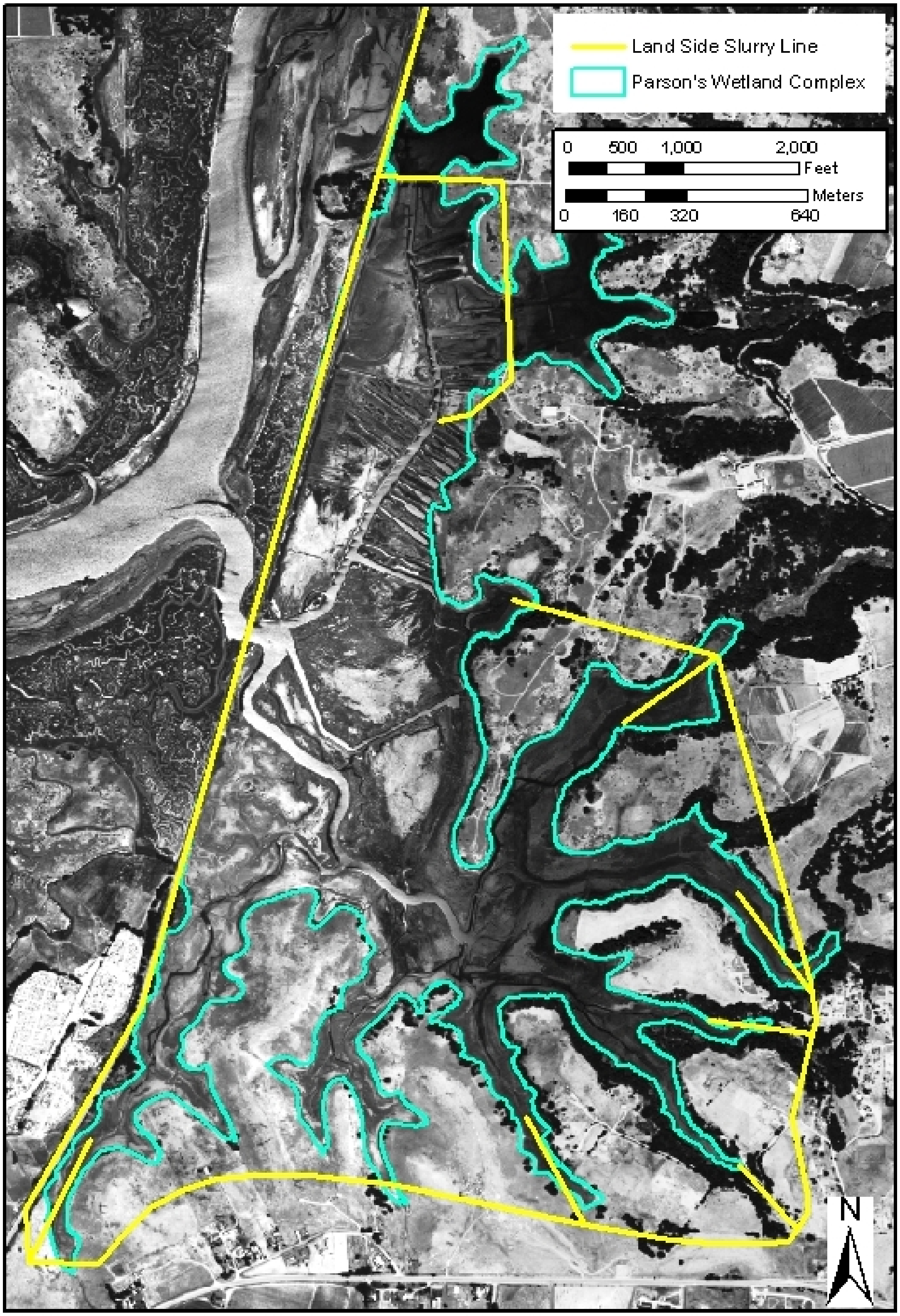


Figure 3-33 – Parsons Slurry Line Distribution on Land

Sediment Grain Size

The grain size distribution of the material appears to change as it weathers. Specifications of the material provided by the Quarry show approximately 80% of the material is finer than sand, while 95% of material retrieved from a surficial sample from Soda Lake was finer than sand. The decrease in mineral grain size at Soda Lake compared to the Quarry may also have been due to mechanical sorting at the lake by water circulation or even rainfall. Sandy material tends to dry out faster than finer-grained material, which may improve plant survival but could also potentially reduce invertebrate community diversity and abundance. For these reasons, fill material with a grain size distribution weighted in favor of silt- and clay-sized particles is preferable to sand-sized material. Further investigation of the granite dust could reveal the rate at which it weathers, which could help determine whether or not enrichment by material with a different grain size is justified.

Approach to Soil Amendment

Several approaches exist to amending imported soil that are each discussed below.

Import organic material and mix with the new sediment on-site - Nearby sources of organic material include manure and greenwaste from vegetable processing facilities. Adding organic carbon in sufficient quantities to enrich the granite dust is unlikely to be economical on the scale of the whole site.

Add existing organic matter on-site at the marsh to the imported soil - Managed organic enrichment could be accomplished most efficiently by using on-site organic material such as pickleweed and algae. Collecting and integrating these materials into the granite dust prior to fill placement may be problematic.

Phase fills to allow plant establishment between phases to increase organic content of new sediment - Implementing a phased fill placement regime where initial deposits are allowed to be colonized by plants before subsequent rounds of fill placement would increase organic matter content in fills. This is a practical approach that may have regulatory constraints and is therefore recommended for consideration with the caveat that regulators need to be consulted about its efficacy. Staff of the Department of Fish and Game, Regional Water Quality Control Board, and the Coastal Commission indicated it may be viable subject to mitigation and realization of long-term benefits relative to short-term impacts (Krause, von Langen, and Morange, Personal Communication, 2008).

Cap soil with on-site surface marsh sediments - Another approach is to remove and stockpile a thin layer of marsh soil and either mix it with the fill or use it to cap the fill. This approach is costly and requires available space and is not recommended.

Cap soil with dredged harbor sediments when available – Using sediment dredged from Moss Landing harbor or other harbors as a cap for fill could improve the organic content of fill soils. This approach would be most cost effective and least environmentally impacting and is recommended.

Specific design issues such as the thickness of the surface cap and the ratio of granite dust to native mud still need to be determined and can be done as a part of subsequent studies. In addition, pilot studies using imported granite dust should be performed on-site before conducting any potential enrichment activities on a large scale within the Parsons Complex.

3.4.8. Cost/Benefits of Alternatives

Analyses of costs and benefits of alternatives is a useful tool for determining if restoration actions are economically justified. Analyses are provided for costs to place fill versus benefits of increased marsh area created and reduction in tidal prism. Construction cost estimates, marsh areas created, and tidal prism reductions were used as the basis of these analyses. Table 3-15 shows all cost and benefit numbers referred to in this section.

The cost per acre or restoring marsh for Alternative 2 are lower than most other fill scenarios except filling of the 6^{th} Finger under Alternative 3 due to the large habitat area created. The cost per tidal prism reduction for Alternative 2 is lower than all other scenarios due to the significant tidal prism reduction realized by this alternative. The costs per acre of new marsh and cost per cubic yard of tidal reduction vary between subalternatives for Alternative 3. The most cost-effective scenario to create vegetated salt marsh is filling the 6^{th} Finger, followed by filling of the Five Fingers. The most cost-effective tidal prism reduction is realized by filling of the Five Fingers followed by filling of the 6^{th} Finger.

3.4.9. Preliminary Environmental Review

Preliminary environmental review is provided to determine any potential fatal flaws of the project alternatives. Potentially significant impacts are identified, along with possible mitigation options. This review includes predictions about changes to water quality (i.e. turbidity, dissolved oxygen, nutrients, salinity) and ecology (i.e. future habitat composition and changes to key indicator species such as benthic invertebrates, sharks/rays, and listed species).

3.4.9.1. No Project

For the No Project Alternative there would be no construction impacts because no construction activity is proposed for restoration.

Table 3-15 – Costs/Benefits of Sediment Addition Alternatives

PARSONS COMPLEX WETLAND RESTORATION PLAN
COSTS/BENEFITS OF RECOMMENDED ALTERNATIVES

Alternative				Increase in Vegetated Salt Marsh ($ per Acre)			Cost Per Tidal Prism Reduction ($ Per Cubic Foot)		
	Area (Acres)	Construction Cost to Fill* (Assuming Containment Dilkes Are Included)	Quantity to Fill (Cubic Yards)	Total Acres of New Vegetated Marsh	Square Feet of New Marsh Per Cubic Yard of Fill	Cost Per Acre of New Marsh	Total Tidal Prism Reduction (Cubic Feet)	Cubic Feet of Tidal Prism Reduction per Cubic Yard of Fil Added	Cost Per Cubic Foot of Tidal Prism Reduced
2 - Sill With Fill	460	$31,265,000	2,300,000	276.0	5.2	114,000	48,700,000	21	$0.6
3A(5) – 6th Finger	34	$2,148,000	124,000	27.0	9.5	80,000	2,300,000	19	$0.9
3B(5) – Five Fingers	144	$9,671,000	718,000	85.0	5.2	114,000	14,900,000	21	$0.6
3C(5) – South Marsh	26	$2,980,000	142,000	11.0	3.4	271,000	2,900,000	20	$1.0
3D(5) – Rookery	25	$2,141,000	151,000	8.0	2.3	268,000	3,200,000	21	$0.7
3E(5) – All Areas (Not Including Central Areas)	229	$16,940,000	1,135,000	131.0	5.0	130,000	23,300,000	21	$0.7

* Construction costs do not include "soft costs" of permitting, environmental review, engineering design, construction management and cost escalation.

"Soft costs" for alternative 2 are approximately $19,134,000, assuming the option with containment dikes.

"Soft costs" for alternative 3 are $10,873,000, assuming the option with containment dikes.

Long-Term Environmental Effects

Within the next 5 years, the environment in the Parsons Complex under the No Project Alternative would remain similar to the existing condition. The subtidal and mudflat habitats would support foraging and nursery areas for sharks and rays. Threatened sea otters would forage in the Complex, including Whistlestop Lagoon. Endangered brown pelicans would feed on fishes within the Complex and would roost on the islands in South Marsh. California least terns would occasionally forage in the Complex during migration and Federal threatened western snowy plovers may at times forage on the mudflats. However, as was described above in Section 3.3.2, over time, probably within the next 20 years, the continual erosion and resulting widening and deepening of the channels would be expected to result in a loss of many of the existing functions in the Parsons Complex. The channels likely would cease to function as nursery areas for sharks and rays. Clam populations may be lost from the deeper, more scoured channels and thus the area would degrade as foraging habitat for sea otters. Erosion of mudflats would result in a loss of foraging habitat for snowy plovers and other shorebirds, and a reduction in the prey birds of American peregrine falcons. The increase in subtidal habitat would increase foraging opportunities for endangered brown pelicans, least terns, and other seabirds. However, the South Marsh islands would continue to erode resulting in a loss of roosting habitat for brown pelicans, cormorants and other waterbirds.

3.4.9.2. Alternative 1 – Structure and All Subalternatives (1A – 1E)

Construction Impacts

Construction of the structure probably would be done from a barge. The material for the structure would be placed directly in the water. Impacts to benthic invertebrates would consist of burying sedentary and slow-moving organisms beneath the sill and generation of a relatively minor amount of near-bottom turbidity when materials are placed on the slough floor. During construction activities, there will be a number of temporary environmental effects. These include temporary impacts on air quality, noise, aesthetics, recreation, water quality, and biology.

Construction equipment and associated vehicles (trucks, worker cars) and vessels emit air pollutants. Total emissions are related to the number of each piece of equipment that is used, the number of hours per day of construction and the total duration of construction activities. Mitigations to reduce air pollutants include applying Best Available Control Technologies.

Mobile organisms such as crabs, fishes, marine mammals, and birds will be disturbed by construction activities and most likely will avoid the construction site. Organisms in the area where the new structure would be constructed will be killed.

The noise of construction equipment will disturb humans and animals nearby. Noise can be reduced by the use of mufflers on equipment or, if necessary, erection of temporary sound walls.

Operation of construction equipment near and in the water has the potential to leak or spill fuels and other contaminants into the water. Placement of coffer dams and other structures would disturb sediments and generate temporary turbidity. Turbidity will temporarily disturb marine organism near the construction area.

Construction activities may interfere with use of the area by recreational users. The presence of construction equipment may temporarily degrade the natural character of the area. Construction activities near the bridge have the potential to interfere with UPRR operations.

Placement of fill in the Five Fingers and between the islands of South Marsh would disturb the areas where the fill would be placed. Birds that use the South Marsh islands for roosting probably would be displaced during construction activities there. Sediment would probably be delivered by road increasing traffic and safety concerns on local roadways. Construction vehicles and trucks delivering sediment may interfere with traffic in the area, and large trucks may create a safety hazard by restricting visibility of cars behind them. In addition, cars may try to pass slow-moving trucks. The impacts of truck traffic could be reduced by restricting truck traffic to non-peak hours and limiting the number of trucks on the road at any one time.

Construction in the Five Fingers area would be done by building a road across the area where the structure would be constructed. Sediment probably would be added by discharging it from various points around the Five Fingers. The presence of construction equipment and stockpiled sediments may temporarily degrade the natural character of the area.

The placement of sediments will bury benthic organisms. If placement rate is slow some organisms may be able to survive by climbing up through the new sediment. Most likely sediment placement will be rapid and most buried organisms will die. In addition, the change in elevation will change the type of organisms living in the sediment placement area. The placement of new sediment is likely to favor invasive non-native benthics, which are adapted to rapidly colonize available areas. Sediment placement will generate turbidity which may affect organisms in adjacent areas by reducing light levels, clogging breathing and feeding appendages, and interfering with visual foraging. Turbidity can be reduced by using silt curtains during sediment placement.

The creation of access roads and stockpile areas will disturb terrestrial habitats. Access roads and stockpile areas should be located to avoid sensitive biological resources. Disturbed areas should be revegetated with native species. If sediment were obtained by scraping the hillsides, further disturbance to terrestrial habitats will occur. Areas denuded of vegetation for access roads or stockpiling may be subjected to erosion and washing of sediments into the water. Disturbed areas should be revegetated to prevent erosion.

Construction equipment and activities may interfere with activities at the Reserve. Impacts could be minimized by designing construction areas and access to minimize interference with visitor use of the Reserve.

Long-Term Environmental Effects

The installation of culverts to mute the tides might interfere with the movements of fishes and wildlife including elasmobranchs and sea otters. Culverts will not necessarily prevent fish migration into and out of the Parsons Complex but they may restrict the movement of some species. Colorado Lagoon in Long Beach, California, has one large diameter culvert. Colorado Lagoon contains a relatively diverse assemblage of marine and estuarine fish species and functions as a nursery area for round stingrays (Chambers Group, 2004). Fishes, including sting rays, also pass through the smaller (4 foot diameter) open culverts from fully tidal Outer Bolsa Bay to muted Inner Bolsa Bay in the Bolsa Chica Wetlands in Huntington Beach (California State Lands Commission, U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers 2001

The upper culverts which would freely allow both inflow and outflow would be relatively small at 2 feet by 4 feet (0.6 to 1.21 m) and would be positioned at 0 feet NAVD. The upper culverts would not have flaps but would be sized and positioned to mute the upper part of the tide range. Therefore, less water (and, presumably, fewer organisms) would enter the Parsons Complex on high tides.

The lower culverts would be relatively large (6 to 10 feet, or 1.8 to 3 m in diameter). However, the lower culverts would have flap gates that only would be open during ebbing tides. The position of the culverts may affect movements because the lower culverts would have flap gates to prevent water from entering during incoming tides. These flap gates could restrict the movements into the Parsons Complex of fishes, such as thornback rays that travel near the bottom. Bottom-dwelling fishes may be discouraged from entering the Parsons Complex during outgoing tides by the force of the outgoing tidal movement although leopard sharks in Elkhorn Slough have been observed to swim against tidal currents (Carlisle, 2006). Systems with one way flap gates to open only at low tide, such as the Ballona Wetlands near Los Angeles and the Santa Ana River Marsh in Orange County tend to support fish assemblages that are almost entirely estuarine and relatively low in diversity (MEC, 2001, L. Louie, personal communication for Santa Ana River Marsh). Although the young of estuarine species such as California halibut apparently enter these systems, larger adults of marine species such as sand bass, sharks and rays tend to be lacking.

The 9 foot (2.7 m) high crest of the structure is likely to restrict the movement of sea otters and harbor seals into and out of the Parsons Complex. Therefore, harbor seals would lose access to their haul out area near the UPRR bridge and sea otters would lose foraging habitat within the Parsons Complex. Sea otters do enter Whistlestop Lagoon which has a dike and culverts so there is some possibility that they would still enter the Parsons Complex through the open culverts. The climb over the dike at North Marsh (Woolfolk, Personal Communication) and would not likely be able to scale the weir at the main channel.

In addition, the 9 foot (2.7 m) high structure would prevent the passage of kayaks or small research vessels into and out of the Parsons complex. Kayaks or small research vessels could access the Parsons Complex only through the Reserve.

Because Alternative 1 would result in a decrease in intertidal mudflat and water area, this alternative would result in a decrease in foraging habitat for sensitive seabirds including the endangered California least tern and endangered California brown pelican, neither of which nest in Elkhorn Slough. This alternative also would result in a decrease in intertidal foraging habitat for the federal threatened western snowy plover, which nests in Elkhorn Slough but not within the Parsons Complex. The reduction in intertidal mudflat habitat would reduce the use of the Parsons Complex by shorebirds and waterfowl and thus might reduce foraging opportunities for the state endangered American peregrine falcon which eats birds and is attracted to large concentrations of shorebirds and waterfowl.

In contrast, the increase in salt marsh and restoration of fairly large areas of contiguous salt marsh habitat might support the use of the Parsons Complex by the endangered California clapper rail. California clapper rails do not presently nest in Elkhorn Slough and have not been documented at the site since the early 1980's.

Alternative 1 would reduce the tidal prism by up to 75% nearly immediately from installation of the structure and no fill, and therefore significantly benefit the entire Elkhorn Slough ecosystem. Lower tidal flow velocities and consequent less erosion and marsh loss would occur with this magnitude of tidal prism decrease. No associated impacts would occur from filling of the site with sediment, however significant increases in transitional and upland areas would be created by exposing existing tidally-influenced areas to subaerial conditions by lowering the high tide elevation.

3.4.9.3. Alternative 2 – Sill With Fill (2A – 2E)

Construction Impacts

Construction of the sill probably would be done from a barge. The impacts of placement of the sill would be similar to those of construction of the structure for Alternative 1. The material for the sill would be placed directly in the water. Impacts to benthic invertebrates would consist of burying sedentary and slow-moving organisms beneath the sill and generation of a relatively minor amount of near-bottom turbidity when materials are placed on the slough floor.

Sediment fill could come from water or land or both. Most likely fill would be placed by land into the Five Fingers, South Marsh, and/or the 6th Finger and the construction impacts of sediment fill in those areas would be similar to those described for sediment fill in these areas under Alternative 1.

Long-Term Environmental Effects

Construction of a sill might interfere with the movement of organisms in and out of the Parsons Complex. Because the crest of the sill would be at -2 feet (-0.6 m) NAVD, it should not restrict the passage of sea otters or harbor seals. However, there might be some impediment for bottom traveling fishes such as thornback rays to swim up over the sill. A sill at -2 feet (-0.6 m) NAVD would not restrict the passage of small research vessels into and out of the Parsons Complex, except at extreme low tides.

Under the scenario in which fill was not contained but allowed to spread out throughout the site, eventually (perhaps by the 20 year mark) most of the central portions of the Parsons Complex would be converted from intertidal mudflat to salt marsh. The conversion of intertidal mudflat to salt marsh would result in a decrease in foraging habitat for sensitive seabirds including the endangered California least tern and endangered California brown pelican, neither of which nest in Elkhorn Slough. This alternative also would result in a decrease in intertidal foraging habitat for the federal threatened western snowy plover, which nests in Elkhorn Slough but not within the Parsons Complex. The reduction in intertidal mudflat habitat would reduce the use of the Parsons Complex by shorebirds and waterfowl and thus might reduce foraging opportunities for the state endangered American peregrine falcon which eats birds and is attracted to large concentrations of shorebirds and waterfowl. As was true for Alternative 1, the increase in salt marsh and restoration of fairly large areas of contiguous salt marsh habitat might support the use of the Parsons Complex by the endangered California clapper rail. California clapper rails do not presently nest in Elkhorn Slough.

Scenarios in which the fill in Alternative 2 was placed behind a dike would remove most of the intertidal mudflat habitat from the diked areas (Five Fingers and/or South Marsh between the islands and/or 6th Finger). These fill scenarios would leave large areas of high quality mudflat in the central portions of the Parsons Complex for foraging by brown pelicans, California least terns, western snowy plovers, and other seabirds and shorebirds. If fill were placed between the islands, the newly created salt marsh habitat in this area would provide increased roosting area for brown pelicans, cormorants, and other birds near to high quality foraging habitat in the western part of South Marsh.

If the fill were contained behind dikes, the mudflat haulout area near the UPRR Bridge would still be available for harbor seals. Foraging habitat for threatened southern sea otters in the Five Fingers would be lost if the Five Fingers were diked and filled, but if the fill were contained sea otters would still have easy access to preferred foraging habitat in Whistlestop Lagoon.

Alternative 2 would reduce the tidal prism by approximately 62% over the long-term if large-scale sediment additions (2.3 million cubic yards) were made to the site. This magnitude of prism decrease would significantly benefit the Elkhorn Slough ecosystem through less erosion and salt marsh loss, but significant potential impacts would occur from filling approximately 250 acres of the site.

3.4.9.4. Alternative 3 – Internal Dikes and All Alternatives (3A[3] – 3E[3])

Construction Impacts

The construction impacts of fill behind a dike in the Five Fingers, the 6th Finger, the Rookery, and/or between the islands in South Marsh would be similar to the impacts described for fill in those areas for Alternative 1. Impacts associated with construction of a structure with tide gates (Alternative 1) or a sill (Alternative 2) near the UPRR Bridge would not occur.

Long-Term Environmental Effects

At 5 to 20 years after restoration, the habitat under Alternative 3 would be similar to that of Alternative 2 with the scenario of fill contained behind dikes in the Five Fingers, the 6th Finger, the Rookery, and/or between the South Marsh islands. However, in contrast to Alternative 2, because there would be no sill, there would be no potential impediments to demersal fish passage in and out of the Parsons Complex. Fill in contained areas behind dikes would leave large areas of high quality mudflat in the central portions of the Parsons Complex for foraging by brown pelicans, California least terns, western snowy plovers, and other seabirds and shorebirds. If fill were placed between the islands, the newly created salt marsh habitat in this area would provide increased roosting area for brown pelicans, cormorants, and other birds near to high quality foraging habitat in the western part of South Marsh. Because the fill would be contained behind dikes, the mudflat haulout area near the UPRR Bridge would still be available for harbor seals. Foraging habitat for threatened southern sea otters in the Five Fingers would be lost if the Five Fingers were diked and filled, but because the fill would be contained, sea otters would still have easy access to preferred foraging habitat in Whistlestop Lagoon.

However, without the placement of a sill, tidal channels would continue to erode and eventually (probably within 20 years), the channels may lose part of their function as nursery habitat for sharks and rays and as foraging area for sea otters. Erosion of channels would result in loss of intertidal mudflats. Loss of intertidal mudflat in the central portions of the Parsons Complex would result in an eventual loss of potential foraging habitat for western snowy plovers and other shorebirds. If concentrations of shorebirds decreased, foraging opportunities for American peregrine falcons also would decrease. On the other hand, increased subtidal area would increase foraging habitat for brown pelicans, least terns and other seabirds.

Each subalternative for Alternative 3, except the no muting option (5), would reduce the tidal prism by approximately 30%. This reduction in the tidal prism would also significantly benefit the site by less erosion and marsh loss. Tidal prism reduction would be accompanied by fill over portions of the site that could impact existing habitat.

3.4.10. Compatibility with Future Sediment Additions to the Wetland Complex and/or Changes to the Tidal Exchange at the Mouth of Elkhorn Slough

The restoration alternatives at the Parsons Complex all need to be compatible with future sediment additions at the Parsons Complex and actions at the main Elkhorn Slough channel. This aspect of the analysis is presented in this section.

3.4.10.1. No Project

The No Project Alternative, by definition, is not compatible with sediment additions to the Parsons Complex because it calls for no action and therefore assumes no sediment will be added. The No Project Alternative is marginally compatible with actions at the main Elkhorn Slough channel. No Project does not pose a direct constraint to restoration actions in Elkhorn and could be compatible with actions proposed downstream. However, maintaining existing conditions at Parsons leaves a tidal prism that is sufficiently large to continue existing patterns of sediment scour and expulsion from the entire wetland system. Without ultimate reduction of the tidal prism or arrest of the scour through the Parsons entrance channel into the Complex, the problem of an ever-increasing tidal prism in Parsons will not only degrade that site, but will continue to increase scour and wetland loss throughout the entire Elkhorn Slough system.

3.4.10.2. Alternative 1 – Structure and All Subalternatives (1A – 1E)

This alternative is compatible with sediment additions at the main Elkhorn Slough channel if they do not raise the slough bed above the inverts of the culverts to Parsons (-10 feet or 3.0 m NAVD). The elevation of the wetland at Elkhorn Slough should remain equal to or below that at Parsons during sediment additions to maintain drainage through culverts from Parsons.

Alternative 1 serves to partially isolate the Parsons Complex from Elkhorn Slough hydraulically and therefore keep the systems indirectly linked. Its performance is entirely dependent on low tides in Elkhorn Slough being maintained and not modified. If low tides at Elkhorn were modified and raised in elevation through any action at Elkhorn, this alternative would no longer function as intended. For example, if the mouth of Elkhorn Slough were relocated to its historic position and allowed to "naturalize," the tidal inlet would be constricted by ocean sedimentation and low tides in Elkhorn would be elevated above existing low tides. This occurs at most natural wetlands without effective jetties (and some with jetties) due to shoaling of sand just inside the wetland mouth and creation of a sill that elevates, or "perches" the low tide elevation (e.g., Huntington Beach Wetlands, Bolsa Chica, Carpinteria Marsh, Malibu Lagoon). A perched low tide condition would cause tides in the Parsons Complex to be unable to drain below those in Elkhorn, thereby further constricting the already small tidal range at Parsons for Alternative 1.

Finally, if tides at the mouth of Elkhorn are controlled by a structure that performs similarly to that considered at Parsons and mute the tides, then a structure at Parsons may no longer be necessary. In that instance, either all tide gates at the Parsons structure could be removed to allow full complete tidal conveyance or the entire structure could be removed.

Reduction in the tidal prism by 75% would significantly reduce tidal scour in the main Elkhorn Slough channel.

3.4.10.3. Alternative 2 – Sill With Fill (2A – 2E)

Alternative 2 is compatible with future sediment additions to the Parsons Complex and actually depends on them to succeed. This alternative is also compatible with actions to add fill and/or relocate the mouth for the larger Elkhorn Slough. The one situation where actions at the main Elkhorn Slough channel could become incompatible with Alternative 2 is if high tides were muted at Elkhorn (and lowered), similar to the proposed Alternative 1 at Parsons. If sediment were added to the Parsons Complex under Alternative 2 to raise the wetland surface elevation, but tides in Elkhorn during the same time period were muted to provide lowered high tidal elevations, the elevation of Parsons could be too high relative to the tides to support salt marsh habitat and the site could transition to upland.

Reduction in tidal prism by 62% would significantly reduce tidal scour in the main Elkhorn Slough channel.

3.4.10.4. Alternative 3 – Internal Dikes and All SubAlternatives (3A[3] – 3E[3])

The design of Alternative 3 is based on muting of the fingers (except the no muting option 5) and possible sediment additions and this alternative is therefore compatible with that action at Parsons. It is also designed to function somewhat independent of actions within the main Elkhorn Slough channel and is therefore also consistent with sediment additions to that system. Finally, it calls for tidal muting in 4 of 5 options in addition to possible sediment additions at the fingers. Therefore, tidal muting this alternative may be incompatible with tidal control or muting options at the main Elkhorn Slough channel if they cause the low tide in Elkhorn to be higher than the existing low tide thus preventing Parsons fingers to drain. In addition, tidal muting options of Alternative 3 are potentially incompatible with the mouth relocation option and the tide structure options considered for Elkhorn if the low tide in Elkhorn is raised by either option. The no muting option of Alternative 3 is compatible with any of the actions referred to above at the Elkhorn Slough.

While this presents the advantage of not having to rely on a “big fix” or cooperation with the UPRR or larger main Elkhorn Slough channel project, the alternative will not address the issue of channel scour through Parsons and Elkhorn, and will allow that process to continue unless some actions are taken to remediate it. If not addressed, that process of sediment scour and loss from the wetland system will eventually degrade the main area of the Parsons Complex further and threaten the integrity of any contained sediment area in the fingers.

Reduction in tidal prism of approximately 30% would significantly reduce tidal scour in the Elkhorn channel.

3.4.11. Considerations of Tidal Muting

Tidal muting is a potential component of restoration at the Parsons Complex. Muting the tides would reduce the tidal prism in Parsons and related tidal flushing, and modify habitat elevations as a function of hydrology. The Parsons Restoration Team has recommended against substantially muting the tides to less than 50 percent of the existing tidal range. Such muting may be appropriate temporarily to establish salt marsh in parts of the Parsons Slough Complex.

Muting portions of the Parsons Complex poses various effects, some beneficial and others detrimental to site conditions. This restoration plan assesses whether to keep tidal muting as an option or whether to drop it all together from future consideration. Considerations of tidal muting are presented below.

Benefits of tidal muting at the Parsons Complex include:

- Reducing the tidal prism in the Parsons Complex and Elkhorn Slough immediately and at a lower cost than alternatives requiring fill;
- Creating salt marsh habitat on areas that are currently mudflat without the direct disturbance of adding fill;
- Converting mudflat to salt marsh and, thus increasing the diversity of the ecosystem and restoring a disappearing habitat; and
- Muted tidal areas could be restored to full tidal regimes at a later date by adding fill and removing water control structures.

Detriments of tidal muting at Parsons include:

- Substantial reduction of habitat value;
- Increased cost and complexity during construction, maintenance, and future adaptive management during sea level rise; and
- Degradation of water quality.

Muted areas that are subsequently converted to full tidal regimes would experience significant impacts to restored vegetated marsh by burial and hydrologic modification. While counter to typical restoration approaches, this approach may actually enrich the organic content of fill soils through decay and increase their fertility, rendering them more able to support vegetative growth. However, there will be a temporary loss in habitat value in the filled areas. Soils should be tested for their ability to grow plants prior to enrichment activities.

Regulatory agencies may not allow temporary interim muting (agencies have been solicited for their opinions and the Department of Fish and Game, Regional Water Quality Control Board, and Coastal Commission have responded, and they are initially open to the concept given the caveat that long-term restoration would outweigh short-term impacts. The approach that agencies could more readily accept is to restore the appropriate tidal inundation frequency regime for the desired habitat and maintain that condition over the long-term.

3.4.11.1. Trade-Offs of Temporary Muting in the Five Fingers

This restoration plan weighs the trade-offs of temporarily restricting tidal exchange in the Five Fingers (as they possess the largest portion of tidal prism within the Parsons Complex). These trade-offs consist of potential impacts to the ecosystem of the Parsons Complex and to the tidal prism of Elkhorn Slough.

3.4.11.2. Qualified Impacts to the Parsons Ecosystem

Potential impacts to the ecosystem of the Parsons Complex from restricting tidal exchange including the following:

- Water quality will be impaired causing stress to fishes and aquatic invertebrates from low dissolved oxygen levels (and potentially higher temperatures) throughout summer and early fall seasons – this may lead to decreased use by leopard sharks that vacate during these periods;
- Salt marsh vegetation would have lower diversity and species richness in muted tidal conditions as compared to full tidal conditions;
- The salt marsh/upland ecotone (transitional areas between adjacent ecological systems) would be narrower in muted areas than in full tidal areas – these areas host high biodiversity by containing characteristics of the adjacent systems and distinctive microhabitats (intensifying cycling of nutrients and facilitating movement of organisms);
- At the Five Fingers, channel and mudflat habitat that is highly used by leopard sharks would be reduced in area by muting, as well as area used by other fishes including rays, invertebrates, and foraging shorebirds and seabirds;
- The diversity and quality of invertebrate prey of sharks and rays, shorebirds, seabirds and sea otters likely will decline resulting in lower quality foraging habitat for water birds, elasmobranchs, and marine mammals; and
- Water control structures may prevent some species such as thornback rays from accessing the muted tidal areas.

Studies of other project sites reveal concerns about tidal muting. According to the U.S. EPA (1988), "Past structural marsh management projects have shown that while it is relatively easy to change marsh hydrology, it is much more difficult to control or manage the changes or to predict fully the consequences of proposed modifications."

3.4.11.3. Impacts to Elkhorn Slough of Deferring Tidal Prism Reduction

The ESNERR may need to undertake a study to identify the impacts to Elkhorn Slough of deferring tidal prism reduction until it can be accomplished using fill placement. Impacts would likely include prolonging existing undesirable conditions of tidal scour and marsh loss, but detailed analysis of this process is beyond the scope of this study. Further assessment of impacts to Elkhorn Slough from deferring tidal prism reduction should be undertaken in the next phase of project planning. Relative to effects at Elkhorn Slough from tidal prism reduction at Parsons, PWA indicates reduced scour would occur in the lower estuary, but habitat areas and distributions would not significantly change from existing conditions over the short-term (PWA 2008).

Some understanding of the effects of muting in the Parsons Complex can be gleaned by comparing the overall tidal prism in Elkhorn Slough with and without muting at the Five Fingers. If the Five Fingers is muted symmetrically (with a 2 foot tide range centered on mean sea level), the overall tidal prism in Elkhorn Slough could decrease by approximately 10%.

3.4.12. Comparison Based on Project Goals and Objectives

Restoration alternatives were analyzed for their consistency with project goals and objectives as compared to existing conditions. Matrices of qualitative alternative performance versus project goals and objectives are shown below. The terms high, medium, and low are assigned to ability of the alternatives to meet project objectives. Tables 3-16, 3-17, and 3-18 show an assessment of Alternative 1 and subalternatives, Alternative 2, and Alternative 3 and all subalternatives, respectively.

Table 3-16 – Assessment of Alternative 1 for Consistency with Project Objectives

	Parsons Alternatives Analysis - Consistency Determination						
	Alternative 1 and Subalternatives						
Goals & Objectives	Description	Consistency Ratings for Restoration Alternatives					
		No Project - Existing Conditions	Subalternative - Structure Only	Subalternative 1B - Structure & Five Fingers Fill	Subalternative 1C - Structure & South Marsh Fill	Subalternative 1D - Structure & Rookery Fill	Subalternative 1E - Structure & All Other Areas Filled
Goal 1	**To restore and enhance intertidal marsh habitats and functions within the Parsons Slough tidal wetland complex while addressing the needs of special-status species, estuarine-dependent species, and ongoing human uses.**						
Objectives:							
1.1	Physical conditions that support intertidal marsh	Low	High	High	High	High	High
1.2	Sediment additions and/or water control structures to support intertidal marsh	Low	High	High	High	High	High
1.3	Protect threatened and endangered species, estuarine-dependent species	Low	Medium	Medium	Medium	Medium	Medium
Incorporate the following concepts:							
1.4a	Natural processes such as re-establishing natural sedimentation	Low	Low	Low	Low	Low	Low
1.4b	Minimize active operations and maintenance	Low	Low	Low	Low	Low	Low
1.4c	Flexible site management	Low	Low	Low	Low	Low	Low
Do not negatively impact:							
1.5a	Non-native species management	Low	Low	Low	Low	Low	Low
1.5b	Seawater intrusion reduction	Low	High	High	High	High	High
1.5c	Scour and flooding on the railroad	Low	?	?	?	?	?
1.5d	Existing human uses: kayaking, boating, fishing, and the harbor	High	Low	Low	Low	Low	Low
1.6	Minimize adverse water quality conditions	Low	Low	Low	Low	Low	Low
1.7	Accommodate up to 3 feet of sea-level rise	Low	Low	Low	Low	Low	Low
1.8	Phased implementation	Low	Low	Medium	Medium	Medium	Medium
Goal 2	**To support the ecological recovery of the larger Elkhorn Slough system while meeting Goal 1.**						
Objectives:							
2.1	Produce physical conditions that support intertidal marsh	Low	High	High	High	High	High
2.2	Adaptive Site Management	Low	Low	Low	Low	Low	Low
Goal 3	**To conserve high quality subtidal and intertidal estuarine habitats and functions within the Parsons Slough tidal wetland complex.**						
Objectives:							
3.1	Accommodate habitat for estuarine fish species	Low	Low	Low	Low	Low	Low

Table 3-17 – Assessment of Alternative 2 for Consistency with Project Objectives

Parsons Alternatives Analysis - Consistency Determination				
Alternative 2 and Subalternatives				
Goals & Objectives	**Description**	**Consistency Ratings for Restoration Alternatives**		
		No Project - Existing Conditions	**Subalternative 2A - Sill Only**	**Subalternative 2A-E - Sill & All Areas Filled**
Goal 1	**To restore and enhance intertidal marsh habitats and functions within the Parsons Slough tidal wetland complex while addressing the needs of special-status species, estuarine-dependent species, and ongoing human uses.**			
Objectives:				
1.1	Physical conditions that support intertidal marsh	Low	Low	High
1.2	Sediment additions and/or water control structures to support intertidal marsh	Low	Low	High
1.3	Protect threatened and endangered species, estuarine-dependent species	Low	High	High
Incorporate the following concepts:				
1.4a	Natural processes such as re-establishing natural sedimentation	Low	Medium	Medium
1.4b	Minimize active operations and maintenance	Low	Medium	Medium
1.4c	Flexible site management	Low	Medium	Medium
Do not negatively impact:				
1.5a	Non-native species management	Low	High	Low
1.5b	Seawater intrusion reduction	Low	Low	Medium
1.5c	Scour and flooding on the railroad	Low	High	High
1.5d	Existing human uses: kayaking, boating, fishing, and the harbor	High	Medium	Medium
1.6	Minimize adverse water quality conditions	Low	High	High
1.7	Accommodate up to 3 feet of sea-level rise	Low	Low	Medium
1.8	Phased implementation	Low	Low	High
Goal 2	**To support the ecological recovery of the larger Elkhorn Slough system while meeting Goal 1.**			
Objectives:				
2.1	Produce physical conditions that support intertidal marsh	Low	Low	High
2.2	Adaptive Site Management	Low	Low	Medium
Goal 3	**To conserve high quality subtidal and intertidal estuarine habitats and functions within the Parsons Slough tidal wetland complex.**			
Objectives:				
3.1	Accommodate habitat for estuarine fish species	Low	Medium	Medium

Table 3-18 – Assessment of Alternative 3 for Consistency with Project Objectives

Goals & Objectives	Description	Consistency Ratings for Restoration Alternatives					
		No Project - Existing Conditions	Subalternative 3B1 - Extreme Muting at Five Fingers - No Sediment	Subalternative 3B2 - Significant Muting at Five Fingers - Limited Sediment	Subalternative 3B3 - Moderate Muting in the Five Fingers and 6th Finger - Extensive Sediment	Subalternative 3B4 - Symmetrical Muting - Significant Sediment & Tidal Prism Reduction	Subalternative 3B5 - No Muting - Significant Sediment & Less Tidal Prism Reduction
			Muting Option 1	Muting Option 2	Muting Option 3	Muting Option 4	No Muting Option 5
Goal 1	**To restore and enhance intertidal marsh habitats and functions within the Parsons Slough tidal wetland complex while addressing the needs of special-status species, estuarine-dependent species, and ongoing human uses.**						
Objectives:							
1.1	Physical conditions that support intertidal marsh	Low	High	High	High	High	High
1.2	Sediment additions and/or water control structures to support intertidal marsh	Low	High	High	High	High	High
1.3	Protect threatened and endangered species, estuarine-dependent species	Low	Medium	Medium	Medium	Medium	High
Incorporate the following concepts:							
1.4a	Natural processes such as re-establishing natural sedimentation	Low	Medium	Medium	Medium	Medium	High
1.4b	Minimize active operations and maintenance	Low	Low	Low	Low	Low	High
1.4c	Flexible site management	Low	Medium	Medium	Medium	Medium	High
Do not negatively impact:							
1.5a	Non-native species management	Low	Low	Low	Low	Low	Low
1.5b	Seawater intrusion reduction	Low	High	High	High	High	Medium
1.5c	Scour and flooding on the railroad	Low	High	High	High	High	High
1.5d	Existing human uses: kayaking, boating, fishing, and the harbor	High	Medium	Medium	Medium	Medium	High
1.6	Minimize adverse water quality conditions	Low	Low	Low	Low	Low	High
1.7	Accommodate up to 3 feet of sea-level rise	Low	Low	Low	Low	Low	High
1.8	Phased implementation	Low	High	High	High	High	High
Goal 2	**To support the ecological recovery of the larger Elkhorn Slough system while meeting Goal 1.**						
Objectives:							
2.1	Produce physical conditions that support intertidal marsh	Low	Medium	Medium	Medium	Medium	High
2.2	Adaptive Site Management	Low	Medium	Medium	Medium	Medium	High
Goal 3	**To conserve high quality subtidal and intertidal estuarine habitats and functions within the Parsons Slough tidal wetland complex.**						
Objectives:							
3.1	Accommodate habitat for estuarine fish species	Low	Low	Low	Low	Low	High

3.5. Summary

This report describes three restoration alternatives for the Parsons Complex and the No Project Alternative, and evaluates their performance with regards to:

- Hydrology/Hydraulics.
- Water Quality.
- Sea Level Rise.
- Habitat Changes (Quantity and Quality).
- Impacts to UPRR Infrastructure.
- Maintenance Requirements and Costs.
- Construction Costs.
- Environmental Impacts.
- Compatibility with Sediment Additions and Actions at Elkhorn Slough.
- Consistency with Project Goals and Objectives.

A summary of pros and cons for each alternative is provided at the end of this section.

Results are summarized below by alternative. All restoration alternatives can roughly achieve targets for tidal elevations and tidal prism. Alternatives 1, 2, and 3 can all reduce peak flow velocities in the entrance channel. The alternatives also create desired habitat changes, with varying quality. They vary in all of the other categories of analysis and more detail is provided below.

3.5.1. No Project

The No Project condition provides no benefits other than no disturbance occurring over the short-term to implement improvements. All existing conditions of entrance channel scour, marsh sediment loss, and associated transition of vegetated marsh into mudflat and subtidal habitats will continue to occur. Eventually, the entire site will convert to subtidal habitat, the tidal prism will maximize, flow velocities will rise, and marsh area will be lost entirely. Annual maintenance costs could range from between $0 to $25,000 for this alternative.

3.5.2. Alternative 1 – Structure and All Subalternatives (1A – 1E)

Alternative 1 depends on muting the tides to create habitat area, with filling of subareas. This alternative immediately reduces tidal prism to a very significant degree, allows for broad flexibility in restoring vegetated salt marsh at Parsons, and solves the basic problem of entrance channel scour. It results in a nearly immediate benefit of salt marsh creation, and allows for fill to be placed in Parsons. Alternative 1 meets the hydrology/hydraulic and habitat needs of restoration over the short-term, and may be adapted to continue to meet these needs over the next 20 years. The structure is designed to be as adaptive as possible to provide flexibility in use, yet it may be technically and physically infeasible for it to function as desired over the very long-term (100 years or more) with sea level rise. Fill would have to occur behind the structure to keep pace with mean water level rise in the Complex if vegetated marsh habitat were to be retained during the future. This alternative may also lead to water quality concerns due to its small tidal range and restricted flushing. Whistlestop Lagoon will be converted from its present subtidal condition to salt marsh which meets a general objective, but removes the site's value for use by marine mammals.

Alternative 1 is consistent with certain actions being considered for the main Elkhorn Slough channel, but may not be consistent with actions that would raise the elevation of the low tide in Elkhorn.

This option would be fairly maintenance and management intensive for its success. Project construction costs are relatively high.

Alternative 1 presents practical concerns regarding the guaranteed capability of the structure to maintain equal hydraulic head on both sides of the UPRR levee. Ramifications of malfunction or imperfect performance of the structure in maintaining the hydraulic head along the rail levee during high water would be serious. Guaranteed performance of the structure require either automated gates controlled by computer programs or manual gates controlled by operators. While the computer program may function well, the mechanical gate structures are never absolutely fail-safe and require manual back-ups that the ESNERR would be required to operate. The ESNERR will have to invest some time and effort into managing the system, and accept liability for potential failure of the structure's performance.

Intensive maintenance of the structure will be required to ensure its long-term performance. Annual maintenance costs may range between $45,000 and $235,000 for this alternative. It also would impede fish passage and connectivity to Elkhorn for small boats.

3.5.3. Alternative 2 – Sill With Fill (2A – 2E)

Alternative 2 allows for restoration on a large-scale and also in increments, while not being constrained significantly by other potential actions in Parsons or the main Elkhorn Slough channel. It would maintain the hydraulic gradient along the railroad levee during high water, and would allow for incremental marsh infilling in addition to any large-scale sediment additions. Alternative 2 addresses the fundamental problem of channel scour and marsh sediment loss. It does not initially reduce the tidal prism, but would eventually reduce it over the long-term if fill occurred in the marsh to raise elevations. This alternative may depend on a series of actions over the long-term, with less immediate short-term benefit to the larger Elkhorn Slough area, but it has the potential for significant long-term benefit to the larger system if the entire area is effectively raised. It does also provide for the benefits of immediate short-term improvements by filling of individual fingers of smaller areas.

Habitat can be created from infilling behind dikes. The sill at the entrance and any internal dikes can be designed to be raised during sea level rise to maintain the desired grade, assuming fill is added behind them. Water quality is maintained as it exists. Tidal prism will be reduced by infilling behind the sill, and tidal flow velocities should decrease as the prism declines, although the numerical model did not indicate that velocity reduction will occur.

Alternative 2 is consistent with all other actions being considered for the main Elkhorn Slough channel. This option should be less maintenance and management intensive than alternatives with culverts and flap gates. Annual maintenance costs may range between $25,000 and $310,000 for this alternative. Alternative 2 is the lowest cost alternative initially, but then increases steadily with incremental additions and it is the highest cost alternative to build over the long-run.

3.5.4. Alternative 3 – Internal Dikes and All Subalternatives (3A[3] – 3E[3])

Alternative 3 relies on the combination of filling and muting for 4 of 5 options to create habitat. This alternative will not address the issue of channel scour through the Parsons Complex, and may allow that process to continue. However, Alternative 3 will immediately reduce the tidal prism with sediment addition and tidal muting (except for the no muting option). As such, it can provide immediate short-term benefits, but may pose a long-term problem if no solution to the main Elkhorn Slough channel is implemented. The long-term efficacy of a project that does not solve the fundamental problem of sediment loss downstream of the site may be questionable.

Alternative 3 functions to enable restoration internal to the Parsons Complex while not having to depend on actions at the main entrance channel to Parsons or within the main Elkhorn Slough channel. This presents the advantage of not having to rely on a “big fix” or cooperation with the UPRR or larger Elkhorn project. This alternative can be adapted to respond to sea level rise though actions at the fingers. It requires maintenance at structures, and annual maintenance costs may range between $85,000 and $730,000 for this alternative. The construction cost of this option is intermediate between the other alternatives in the long run as tide control is required at multiple sites for 4 of the 5 options.

3.5.5. Summary of Pros and Cons

The pros and cons of each alternative are briefly described below for further consideration.

3.5.5.1. No Project

Pros for No Project are that:

- No initial cost or impact will occur from a project.
- Existing high value habitat for fisheries and marine mammals will be preserved.

Cons for No Project are that:

- The site lacks habitat diversity and would never recover in diversity.

The existing problems of marsh loss and tidal prism increase (and all other associated problems) will be perpetuated until it becomes entirely subtidal, particularly with sea level rise occurring.

3.5.5.2. Alternative 1 – Structure and All Subalternatives (1A – 1E)

Pros for Alternative 1 are that:

- It should create large habitat areas over the short-term without the need to fill.
- A structure already exists to anchor a structure.
- Addresses the basic problem of channel scour and marsh sediment loss.
- It significantly reduces tidal prism and benefits the entire Elkhorn Slough.
- It presents the broadest possible options of all alternatives for adaptive management, from extreme muting of the site to no muting of the site (if gates are removed or entirely opened).

Cons of Alternative 1 are that:

- It requires UPRR participation/permission.
- The structure requires maintenance to function.
- Performance is dependent on maintenance and is potentially vulnerable to mechanical failure in performance, with serious consequences (UPRR levee stability).
- The action is high cost.
- The action degrades water quality.
- The structure requires modification to accommodate sea level rise and may not be viable for the very long-term.

- It blocks passage of certain fish and marine mammals.
- It may be inconsistent with relocation of the Elkhorn Slough mouth, tidal muting at the mouth of Elkhorn, and/or sediment additions if those actions result in a higher elevation of average and spring low tides and/or the Elkhorn Slough bed.

3.5.5.3. Alternative 2 – Sill With Fill (2A – 2E)

Pros of Alternative 2 are that it:

- Is a low-cost and low-maintenance structure.
- Addresses the basic problem of channel scour and marsh sediment loss.
- Results in more natural habitat conditions over the long-term with sediment additions.
- Can be adapted by raising to accommodate sea level rise and still retain sediments.
- Includes a sill that is high relative to the bed, thus the wetland sediment bed may rise high and at a rapid rate.
- Allows for incremental fill additions at the fingers, South Marsh cells, and the Rookery.
- Does not depend on mechanical performance and thus is not vulnerable to failure.
- maintains existing water quality.
- Is compatible with most Elkhorn actions, except any potential muting of the high tide at Elkhorn Slough.

Cons of Alternative 2 are that it:

- Requires large quantities of fill that may be very expensive and may be impacting to the surrounding area to completely raise the site (although it can also be done in increments).
- Causes significant habitat impacts from filling.
- May not show immediate short-term benefits without the fingers being incrementally filled.
- Minimally reduces tidal prism in Elkhorn Slough unless large quantities of fill are added.

3.5.5.4. Alternative 3 – Internal Dikes and All Subalternatives (3A[3] – 3E[3])

Pros of Alternative 3 are that:

- It creates large habitat areas without having to place extremely large quantities of fill.

- All work done will remain within property owned and operated by the ESNERR and actions can remain somewhat independent of the UPRR.
- It mutes the tide to benefit the overall Elkhorn Slough (except for the no muting option).

Cons of this alternative are that:

- It affects tidal flushing and water quality (except for the no muting option).
- It leads to impacts from filling.
- It does not address the problem of channel scour and therefore may limit the amount of fill that can accumulate within the wetland in the future and correspondingly limit the extent of restoration that can feasibly occur.
- Any sediment addition to this site that is not behind a containment feature may not as readily remain the marsh for the long-term, however this should be researched with pilot projects.
- Restoration can effectively occur as a benefit within contained areas, but not throughout the entire marsh.

3.6. References

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APPENDIX 3-A - ITEMIZED COST ESTIMATES FOR SLURRY SEDIMENT DELIVERY OPTIONS

CONSTRUCTION COST ESTIMATE
Sediment Slurry Line Installation - Elkhorn Return Water
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$600,000.00	$600,000
	Installation				
2	Main Pumps (one each for the slurry and the return water) (Assumes existing pump at Graniterock is usable)	1	Each	$100,000.00	$100,000
3	Booster Pumps	6	Each	$50,000.00	$300,000
4	14-Inch HDPE Discharge Line	68,640	Feet	$70.00	$4,804,800
5	(Includes trenching and backfill to bury line)				
6	14-Inch HDPE Return Water Line from Elkhorn Slough	68,640	Feet	$70.00	$4,804,800
7	(Includes trenching and backfill to bury line)				
8	Right of Way Lease or Purchase	205,920	Square Feet	$15.00	$3,088,800
9	Labor	80	Hours	$200.00	$16,000
10	Equipment	3	Each	$5,000.00	$15,000
	Subtotal Items				**$13,729,400**
	Contingency			25.0%	$3,432,350
	Permits (local agency approvals for construction needs)			1.0%	$137,294
	Environmental Review (Assumed EIR already done for project)			0.0%	$0
	Final Engineering, Bid Documents, Construction Support			5.0%	$686,470
	Construction Management			2.0%	$274,588
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$3,543,415
	SLURRY SYSTEM INSTALLATION GRAND TOTAL				**$21,803,517**
	Quantity of Material Placed				2,300,000
	Cost Per Cubic Yard				$9

CONSTRUCTION COST ESTIMATE
Sediment Slurry Line Installation - Pajaro Return Water
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$300,000.00	$300,000
	Installation				
2	Main Pumps (one each for the slurry and the return water)	1	Each	$100,000.00	$100,000
	(Assumes existing pump at Graniterock is usable)				
3	Booster Pumps	3	Each	$50,000.00	$150,000
4	14-Inch HDPE Discharge Line	68,640	Feet	$70.00	$4,804,800
5	(Includes trenching and backfill to bury line)				
7	14-Inch HDPE Return Water Line from Pajaro River	2,500	Feet	$70.00	$175,000
8	(Includes trenching and backfill to bury line)				
10	Right of Way Lease or Purchase	205,920	Square Feet	$15.00	$3,088,800
11	Labor	50	Hours	$200.00	$10,000
12	Equipment	3	Each	$5,000.00	$15,000
	Subtotal Items				**$8,643,600**
	Contingency			25.0%	$2,160,900
	Permits (local agency approvals for construction needs)			1.4%	$121,010
	Environmental Review (Assumed EIR already done for project)			0.0%	$0
	Final Engineering, Bid Documents, Construction Support			5.0%	$432,180
	Construction Management			2.0%	$172,872
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$2,237,532
	GRAND TOTAL				**$13,768,095**
	Quantity of Material Placed				2,300,000
	Cost Per Cubic Yard				$6

CONSTRUCTION COST ESTIMATE
Sediment Slurry Line Operation, 3.5 Years - Elkhorn Return Water
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Maintain Main Pumps	2	Each	$25,000.00	$50,000
2	Kilowatt Hours (500 horsepower pumps)	14,560	Kwh	$40.00	$582,400
3	Maintain Booster Pumps	6	Each	$5,000.00	$30,000
4	Kilowatt Hours (100 horsepower pumps)	17,472	Kwh	$40.00	$698,880
5	Maintain Pipeline	1	LS	$250,000.00	$250,000
6	Labor - Pumps and Pipes	1	Hours	$200,000.00	$200,000
7	Operation of Discharge Point	1	Hours	$250,000.00	$250,000
	Subtotal Items				**$2,061,280**
	Contingency			25%	$515,320
	Permits			0.00%	$0
	Environmental Review (EIR for the entire wetlands complex)			0.0%	$0
	Final Engineering, Bid Documents, Construction Support			0.0%	$0
	Construction Management			0%	$0
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$499,995
	GRAND TOTAL				**$3,076,595**
	ANNUAL COST				**$879,027**

CONSTRUCTION COST ESTIMATE
Sediment Slurry Line Operation, 3.5 Years - Pajaro Return Water
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Maintain Main Pumps	2	Each	$25,000.00	$50,000
2	Kilowatt Hours (500 horsepower pumps)	14,560	Kwh	$40.00	$582,400
3	Maintain Booster Pumps	3	Each	$5,000.00	$15,000
4	Kilowatt Hours (100 horsepower pumps)	8,736	Kwh	$40.00	$349,440
5	Maintain Pipeline	1	LS	$250,000.00	$250,000
6	Labor - Pumps and Pipes	1	Hours	$200,000.00	$200,000
7	Operation of Discharge Point	1	Hours	$250,000.00	$250,000
	Subtotal Items				**$1,696,840**
	Contingency			25%	$424,210
	Permits			0.00%	$0
	Environmental Review (EIR for the entire wetlands complex)			0.0%	$0
	Final Engineering, Bid Documents, Construction Support			0.0%	$0
	Construction Management			0%	$0
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$411,595
	GRAND TOTAL				**$2,532,645**
	ANNUAL COST				**$723,613**

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APPENDIX 3-B - ITEMIZED COST ESTIMATES OF ALTERNATIVE SEDIMENT DELIVERY OPTIONS

CONSTRUCTION COST ESTIMATE
Trucking of Material
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$0.00	$0
2	Trucking	2,300,000	CY	$11.55	$26,565,000
3	Placement at Each Site	2,300,000	CY	$3.00	$6,900,000
	Subtotal Items				**$33,465,000**
	Contingency			25%	$8,366,250
	Permits			2.50%	$836,625
	Environmental Review (EIR for the entire wetlands complex)			2.5%	$836,625
	Final Engineering, Bid Documents, Construction Support			5.0%	$1,673,250
	Construction Management			3%	$836,625
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$8,929,195
	TRUCKING GRAND TOTAL				**$54,943,570**
	Cost Per Cubic Yard				$24

CONSTRUCTION COST ESTIMATE
Rail Transport of Material
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$0.00	$0
2	Rail Car Loads	35384	Each	$400.00	$14,153,600
3	Terminal Improvements at Offload End	1	LS	$500,000.00	$500,000
4	Haul or Pump to Placement Location	2300000	CY	$3.00	$6,900,000
	Subtotal Items				**$21,553,600**
	Contingency			25%	$5,388,400
	Permits			2.50%	$538,840
	Environmental Review (EIR for the entire wetlands complex)			2.5%	$538,840
	Final Engineering, Bid Documents, Construction Support			5.0%	$1,077,680
	Construction Management			3%	$538,840
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$5,750,973
	RAIL TRANSPORT GRAND TOTAL				**$35,387,173**
	Cost Per Cubic Yard				$15

Notes:

1. Transport cost range per Doug Rubin at M&N NY office.

CONSTRUCTION COST ESTIMATE
Dredge Transport of Material
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$2,000,000.00	$2,000,000
2	Dredging	2,300,000	CY	$7.00	$16,100,000
3	Booster Pump to Site	2,300,000	CY	$3.00	$6,900,000
	Subtotal Items				**$25,000,000**
	Contingency			25%	$6,250,000
	Permits			2.50%	$625,000
	Environmental Review (EIR for the entire wetlands complex)			2.5%	$625,000
	Final Engineering, Bid Documents, Construction Support			5.0%	$1,250,000
	Construction Management			3%	$625,000
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$6,670,548
	DREDGING GRAND TOTAL				**$41,045,548**
	Cost Per Cubic Yard				$18

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APPENDIX 3-C - EVALUATION OF OPTIONS FOR SEDIMENT ADDITIONS TO REBUILD MARSH HABITAT AT THE PARSONS SLOUGH COMPLEX

APPENDIX 3-C

EVALUATION OF OPTIONS FOR SEDIMENT ADDITIONS TO REBUILD MARSH HABITAT AT THE PARSONS SLOUGH COMPLEX

Prepared for:

California State Coastal Conservancy
1330 Broadway Avenue, 13th Floor
Oakland, CA 94612-2530

and

Elkhorn Slough National Estuarine Research Reserve
1700 Elkhorn Road
Watsonville, CA 95076

Prepared by:

MOFFATT & NICHOL
3780 Kilroy Airport Way, Suite 600
Long Beach, CA 90806
(562) 426-9551

In Association With:

Chambers Group, Inc.
Wetland and Water Resources
and
FarWest Restoration Engineering

M&N File: 6266

November 24, 2008

Executive Summary

The Parsons Slough Complex requires 2.3 million cubic yards of sediment additions to raise the existing grade relative to the tides as part of restoration of salt marsh. This report identifies potential sediment sources, presents initial restoration alternatives, prioritizes locations for sediment placement, reviews and evaluates sediment addition techniques, and summarizes regulatory issues associated with these actions.

Sediment sources exist within the region both upland and offshore. Upland sources include materials both within and outside of the watershed. Sources include lakes, agricultural farms, regional road right of ways, development sites, flood control facilities, and quarries. Aqueous sources include local harbors and navigable waterways, the nearshore ocean, and the offshore ocean. A promising source appears to be a local quarry approximately nine miles from the site and accessible by truck and rail. The quarry produces large quantities of a by-product that is fine in grain size and inert in chemistry.

Locations for sediment addition have been prioritized based on a ranking system that considers construction access, available working/staging areas, area of new vegetated marsh created for sediment added, reduction in tidal prism, environmental impacts, proximity to local sources, containment feasibility, and likely construction costs. The priority of placement areas is:

1. The Five Fingers and the 6th Finger as tied for first;
2. Rookery Lagoon;
3. The Larger South Marsh Area; and
4. The Central/West Marsh South of the Main Channel.

Dry material sources lend themselves to trucking and transport by train, with earthmoving as one method sediment. Dry material sources may not possess the biogeochemical properties necessary for establishment of vegetated salt marsh, but could be amended as needed. Wet sediment could be pumped hydraulically to the site. Wet sediment is conveyed in a slurry mixture through a discharge pipeline. Material from aqueous sources, particularly from the marine environment, may be immediately suitable for use in establishing vegetated salt marsh habitat assuming the material grain size is not too coarse (sandy). Non-native invertebrates may exist in harbor sediments thereby presenting a constraint.

Implementing the project requires permits for a defined period of time, such as 5 to 10 years maximum with requirement to re-apply toward the end of the period and submit monitoring results supporting the proposed actions. Such programs have been permitted by all jurisdictional agencies for beach nourishment purposes in three California locations that may serve as examples for this type of project, with certain modifications to the permit structure.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

This Evaluation of Options for Sediment Additions to Rebuild Marsh Habitat at the Parsons Slough Complex is one of the tasks required as part of the Wetland Restoration Plan effort by the Elkhorn Slough National Estuarine Research Reserve (ESNERR), the Elkhorn Slough Foundation, and the California State Coastal Conservancy (SCC). These agencies, stakeholders, and members of other public agencies and the public seek to restore a degraded salt marsh at the location referred to as the Parsons Complex. Wetland restoration planning has included identifying project goals and objectives, and assessing existing conditions and identifying data gaps.

Existing data indicate that the Parsons Complex is significantly lower in elevation than conditions required for establishment of vegetated salt marsh. As a result, this wetland mainly consists of mudflat areas with subtidal channels, and small areas of vegetated marsh along its perimeter and on isolated islands. Working in collaboration, the Parsons Restoration Team (PRT) has identified that possible actions to address the problem of a marsh that too low relative to the tide may include controlling the tidal elevations relative to the marsh surface, and/or adding sediment to raise the marsh surface relative to the tidal elevations.

For planning decisions, this evaluation is prepared to provide information regarding adding sediment in the context of restoration alternatives presently being considered. This report identifies potential sediment sources, presents initial restoration alternatives, prioritizes locations for sediment placement, reviews and evaluates sediment addition techniques, addresses environmental effects and costs, and summarizes regulatory issues associated with these actions. This report is one in a series of publications addressing planning aspects of restoration of the Parsons Complex. The reports present the findings of a progression of planning tasks, and will be bundled together into a final Restoration Plan at the conclusion of the analyses.

1.1 Background

The regional vicinity and general location of the Parsons Complex are shown in Figure 1. The Parsons Complex (including Parsons Slough, the Five Fingers, South Marsh, Whistlestop Lagoon, and Rookery Lagoon) is located on the southeastern side of Elkhorn Slough as shown in Figure 2. Elkhorn Slough is a 2,440-acre wetland complex located on the edge of Monterey Bay, midway between Santa Cruz and Monterey. A portion of the Complex has been designated as a National Estuarine Research Reserve. The entire Parsons Complex is approximately 465 acres in size and the main areas are dominated by mudflat with subtidal creeks, fringing tidal marsh, and created tidal marsh islands. The Parsons Complex was historically a mix of salt marsh, brackish marsh, and transitional freshwater habitats but much of the vegetated salt marsh cover has changed to mudflat. It includes approximately 161 acres of South Marsh and 304 acres of Parsons Slough and the Five Fingers area, all located east of the Union Pacific Railroad (UPRR) line. Figure 3 shows the features within the Parsons Complex and landmarks.

Existing conditions show the low elevation of the site relative to tides and clarifies the habitat types present as a consequence of this situation. The Draft Report of Existing Conditions for the Parsons Slough Complex (Moffatt & Nichol 2007) provides specific data on site elevation and habitat, explains existing processes, and verifies the need to consider addition sediment to increase the elevation of the Complex over time.

1.2 Scope Of Work

The following tasks are included in the contracted scope of work for this project:

1. Establish Goals and Objectives for the Parsons Slough Restoration Plan;
2. Develop Quality Assurance Project Plan;
3. Prepare Existing Conditions Report;
4. Evaluate Options for Sediment Additions to Rebuild Marsh Habitat (this report);
5. Develop and Evaluate Restoration Alternatives; and
6. Prepare the Parsons Slough Complex Wetland Restoration Plan.

This report satisfies scope item number 4. This report constitutes the draft deliverable for the task. Scope items 1 through 3 have already been completed. Work for task 5 will also be completed and submitted as a separate report, with the task 6 being a compilation of all material into a comprehensive restoration plan.

Figure 1 – Regional Vicinity Map

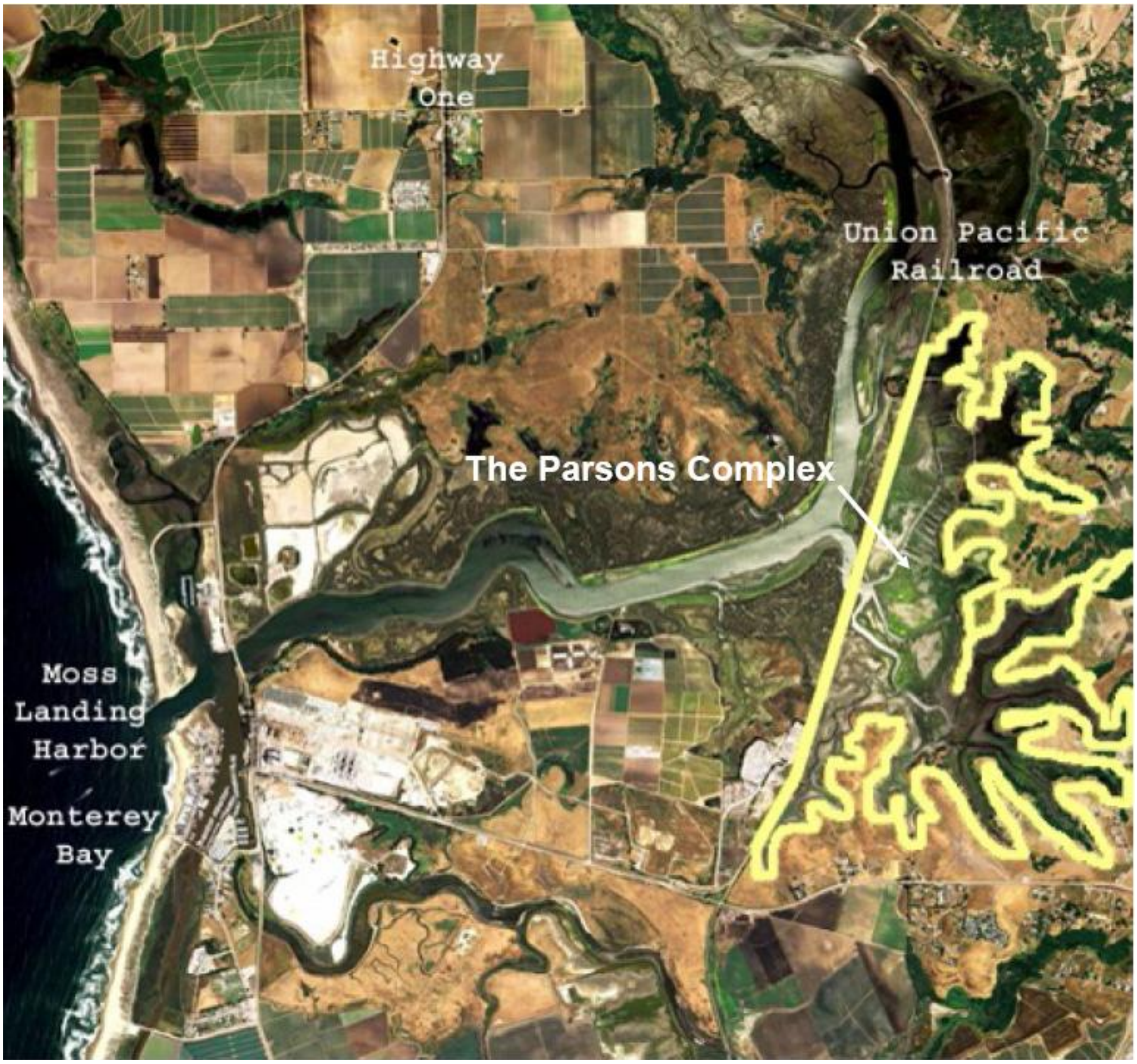

Figure 2 – The Project Location

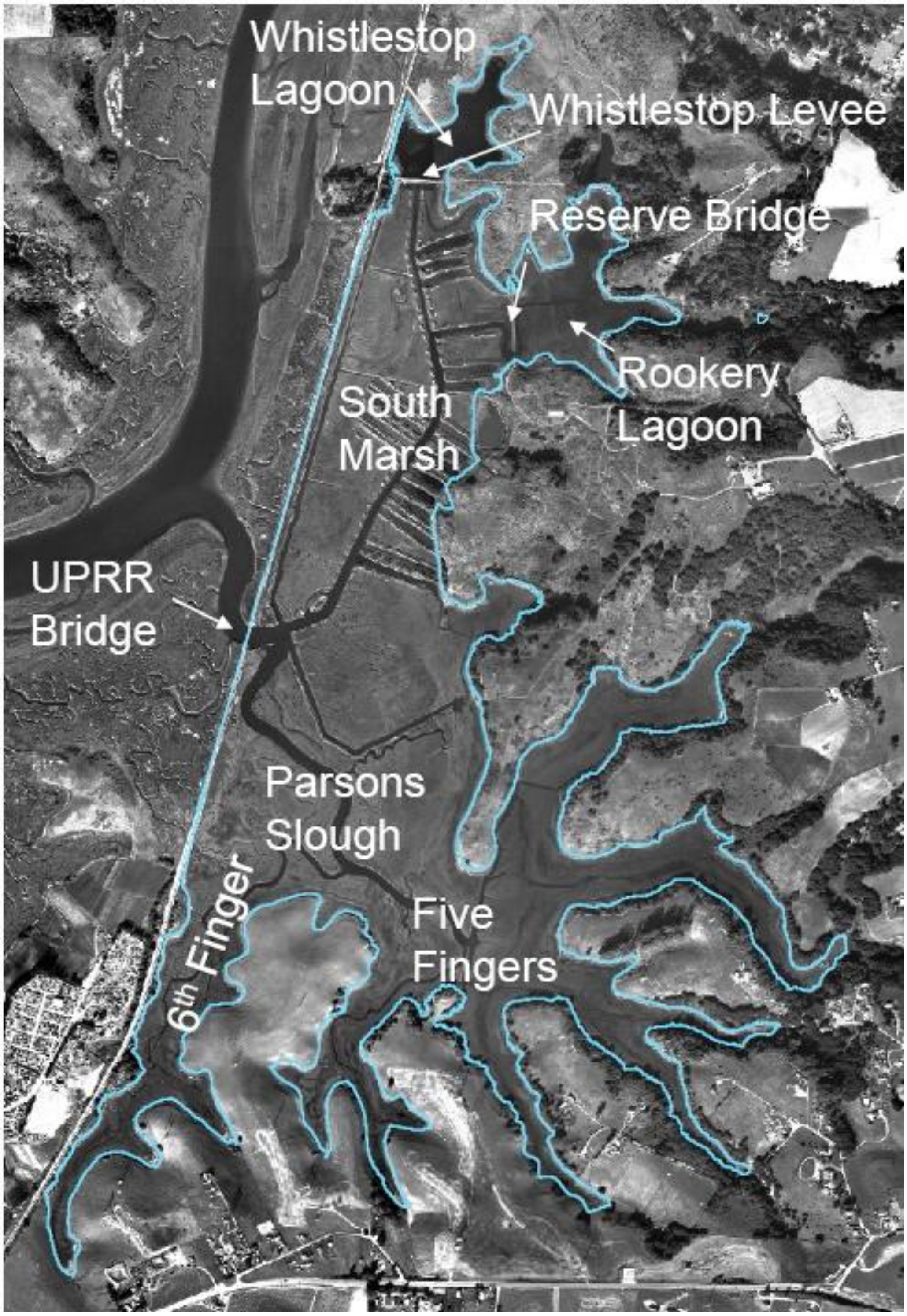

Figure 3 – The Parsons Complex Project Site

2.0 POSSIBLE SEDIMENT SOURCES

Information of sediment suitability considerations, and existing and potential future sediment sources that could be used as fill within areas of Parsons Slough is presented within this section. Sources range from those located within the local watershed, to those within the region and possibly farther away from the site, and those on land and in water. Each source is briefly described below. Research of sediment sources will continue throughout 2008 to identify as many as possible for consideration in the future. Certain information regarding sources is defined, while other information regarding the material properties, the timeframe of their availability and costs for their transport vary and are still being determined.

2.1 Sediment Suitability Considerations

Considerations for the suitability of sediment for use as fill are described below for both dry and wet material.

2.1.1 Dry Material

Research of possible sediment sources for this and other similar studies indicates that the majority of sources are located at upland areas, or in areas located inland from large water bodies. Upland soils can possess biogeochemical characteristics that are different from wetland soils. Typically these soils possess variable grain size, have lower organic matter content, and possess properties of bulk density, pH and salinity that have been developed in a relatively dry environment. Therefore, they may be less suitable for placement as fill to establish vegetated salt marsh habitat. Also, the suitability of soils for use as fill may differ for placement elevation, as the considerations for areas below plant root zones could differ from those within the root zone.

Some upland soils may possess suitable characteristics for establishing marsh habitat. Soils that are fine in grain size with high percentages of silt and clay will be more desirable than sandy soils. Sediment that possesses some measure of organic matter in addition to mineral matter is more apt to provide nutrients necessary for marsh establishment. Materials with contaminants such as those listed in applicable public documents (San Francisco Regional Water Quality Control Board Draft Staff Report 2000; NOAA 1999; and Department of Toxic Substances Control 2001) including pesticides, metals, PCBs, semi-volatile organics, Dioxin/Furin, organotins, oil and grease that are above the Effects Range Medium (ER-M) as defined by NOAA (1999) may not be appropriate for use, to be determined on a case-by-case basis. Soil testing and analysis prior to accepting a particular source should occur to determine if it is suitable as is, or needs some type of amendment or other treatment prior to being placed at the marsh. The use of these soils implies the need for some blending with suitable organic soils, either on-site or other import fill material. Implementing small pilot projects may be one way to identify soils that serve well to raise the marsh and provide conditions to establish vegetated marsh habitat.

2.1.2 Wet Material

Material that exists in a wet environment can initially possess the attributes suitable for use as fill in a wetland. Typically these soils are finer-grained, have higher organic matter content, and pH and salinity levels properties that have been developed in an aqueous environment. Therefore, they may be more suitable for direct placement as fill and still foster establishment of vegetated salt marsh habitat. Sediment from marine systems can be most suitable. Materials with contaminants such as those listed in the Inland Testing Manual (U.S. EPA and U.S. Army Corps of Engineers, 1998) including pesticides, metals, PCBs, semi-volatile organics, Dioxin/Furin, organotins, oil and grease that are above the Effects Range Medium (ER-M) as defined by NOAA (1999) may not be appropriate for use, to be determined on a case-by-case basis.

2.2 Sources within the Elkhorn Slough Watershed

Sites exist locally within the Elkhorn Slough Watershed that serve as possible sediment sources. They consist of local lakes and water bodies, agricultural areas and drainage facilities, and the vacant land immediately adjacent to the Parsons Complex. Table 1 provides an inventory of the sources and Figure 4 shows their approximate locations. Considerations for all sediment sources include sediment suitability for marsh restoration (e.g., grain size, organic matter composition, nutrient levels, and contaminants) and for each source, the quantities that may become available and the time frame of that availability.

2.2.1 Lakes

Werner Lake, located at Garin Road south of Watsonville, is in excess of 5 acres in size and has been filled in with sediment from upstream agricultural activities. The amount of sediment which may be available for placement in the Parsons Complex is estimated to be between 10,000 and 20,000 cubic yards (cy). The Nature Conservancy has ownership of the lake.

2.2.2 Agricultural Areas

The Elkhorn Slough Foundation (ESF) manages approximately 3,600 acres of land in the watershed including some farm lands which have experienced extensive erosion with sand being deposited downstream. A number of sites have been identified where removal of sand could both benefit the land and produce an estimated 10,000-15,000 cy of surplus sediment. Ranches with a history of sedimentation include the Elzas Ranch, the Brothers Ranch and the Chamisal Ranch. All three are located approximately 3 miles to the north of the Parsons Complex.

2.2.3 Quarries

Several quarries existing within the region that yield aggregate material available for filling at the Parsons Complex. The closest quarry to the site is Graniterock Wilson Quarry. That site produces a byproduct called granite dust that is fine-grained granular material suitable for use as fill. This material is inert and may need amendment to be fertile. It is produced at a rate of approximately 650,000 cubic yards per year.

2.3 Upland Sources Within the Region

Several sources exist upland within the central coastal California region. They consist of public and private land being developed or maintained that results in surplus sediment.

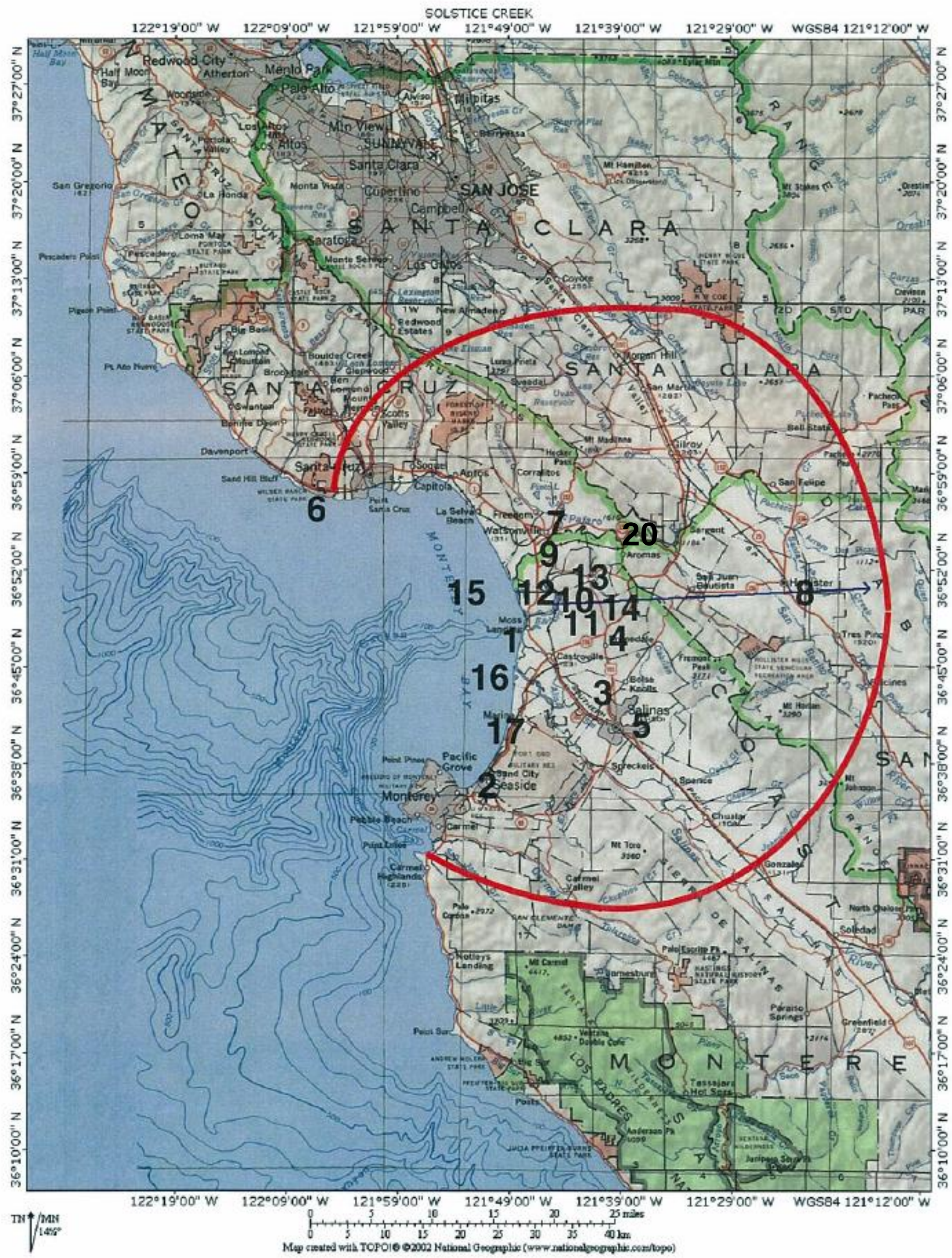

Figure 4 – Sediment Sources in Proximity to the Parsons Complex

Table 1. Parsons Slough Sediment Sources

SOURCE DESIG-NATION	LOCATION	NUMBER ON RADIUS MAP	QUANTITY* (Cubic Yards)	GRADATION Approximate Soil Type	DISTANCE TO PLACEMENT SITE (Miles)	OWNERSHIP	APPROX TIMEFRAME AVAILABLE	TRANSPORTATION COST ($/cubic yard)	COMMENTS	ORGANIZATION	CONTACT PERSON	PHONE NUMBER
ML	Moss Landing Harbor	1	Between 25000 and 41000 c per episode	Sands/silts/clays	c.5	Harbor District	3 yr maint.dredge prog. - next one due in 2010	$4	Need to contact geotech sub for gradation.	Moss Landing Harbor District	Linda McIntyre	(831) 633 5417
MCI	Monterey Harbor	2	75,000 per episode	Sands/silts/clays	c.20/25	Harbor District	Bi or Tri-annual basis	$18	95% medium grain sized sand	City of Monterey	Steve Scheiblauer	(831) 646 3950
MCO	With the Monterey County jurisdiction	3	Unknown	Sands/silts/clays	10	County	Unknown	To be Determined	Gradation generalized from DBAW data	Monterey County Water Resources Agency	Brent Buche	(831) 755 4860
	Monterey County Mosquito Abatement District	3	Unknown	Unknown	10	County	Unknown	To be Determined	Gradation not yet available	Monterey County Mosquito Abatement District	Dennis Boronda	(831) 647 7654
CAL5	District 5	4	Unknown	Unknown	4.0	State	Unknown	To be Determined	Still under investigation	CALTRANS	Jim Shivers	(805) 549 3237
SAL	3 locations: Gabilan Creek, Carr' Lake Detention Basin Monobia' detention basin	5	Unknown	Silt	Gabilan - 10/15 Carr Lake - 10/15 Monoboa -10/15	City	Spring 2008	$12	Gradation not yet available	City of Salinas	Denise Estrada	(831) 758-7152
SCH	Santa Cruz Harbor	6	10,000 - 20,000 cy	Sands/silts/clays	c.25	Harbor District	Summer 2008	$20	Gradation not yet available	Santa Cruz Harbor District	Brian Foss	(831) 475-6161
WAT	Within the City of Watsonville jurisdiction	7	Unknown	Unknown	c.10	City	Unknown	$8	Still under investigation	City of Watsonville	Steve Palmisano	(831) 768 3176
HOL	Within the City of Hollister jurisdiction	8	Unknown	Unknown	c.20	City	Unknown	$17	Gradation not yet available	City of Hollister	Steve Wittry	(831) 636-4340
ES WSHED	Werner Lake	9	10,000 - 20,000 cy	Silts/Clays	5 to 10 miles	The Nature Conservancy	Immediately	$7	Gradation not yet available	Elkhorn Slough NERR	Mark Silberstein	(831) 728-2822
ES WSHED	Local Farmland Erosion	10	10,000 - 20,000 cy	Silts/Clays	Likely within 10 miles	ESNERR/Private	Immediately	$8	Gradation not yet available	Elkhorn Slough NERR	Mark Silberstein	(831) 728-2822
ELKHORN HIGHLANDS	Elzas Ranch	12	3,000 - 5,000 CY	Predominantly sand	c.3	ESNERR	Unknown	$3	Gradation not yet available	Elkhorn Slough NERR	Mark Silberstein	(831) 728-2822
ELKHORN HIGHLANDS	Brothers Ranch	13	3,000 - 5,000 CY	Predominantly sand	c.3	ESNERR	Unknown	$3	Gradation not yet available	Elkhorn Slough NERR	Mark Silberstein	(831) 728-2822
ELKHORN HIGHLANDS	Chamisal Ranch	14	3,000 - 5,000 CY	Predominantly sand	c.3	ESNERR	Unknown	$3	Gradation not yet available	Elkhorn Slough NERR	Mark Silberstein	(831) 728-2822
OFFSHORE	Offshore ocean out to -80' depth	15	Unlimited	Sands/Silts/Clays	c.5	State of California State Lands Commiss.	5-years minimum	$20	Gradation assumed to be sand/silt/clay	State of California State Lands Commiss.	To be determined	To be determined
LITTORAL	Nearshore Ocean	16	400,000 cy/yr	Sands	c.3	State of California State Lands Commiss.	5-years minimum	$15	Gradation assumed to be sand	State of California State Lands Commiss.	To be determined	To be determined
DEVELOP	Marina	17	c.200,000cy/yr	Sands	15-20	To be determined	5-7 yr project	$16	Gradation assumed to be sand	Assured Aggregates	Marty Giovanetti	(831) 443-8644
QUARRY	Felton Quarry	18	Unknown	Granular/top soil	c.25	Granite Construction	Unknown	$20	Estimated cost is $4-$5 per ton	Granite Construction	Ross Kashiwagi	(831) 763-5545
QUARRY	Freeman Quarry	19	Unknown	Granular/top soil	c.18-20	Granite Construction	Unknown	$17	Estimated cost is $4-$5 per ton	Granite Construction	Ross Kashiwagi	(831) 763-5545
QUARRY	Handley Ranch	19	Unknown	Granular/top soil	c.18-20	Granite Construction	Unknown	$17	Estimated cost is $4-$5 per ton			
QUARRY	Graniterock Wilson	20	650,000 CY Annually	Fine Granite Dust	c.9	Graniterock Quarry	Immediately	$6 (Slurry) - $12 (Truck)	Estimated cost is $7 per ton as of 11-3-08	Granite Construction	Ross Kashiwagi	(831) 763-5545

ES WSHED	Elkhorn Slough Watershed
OFFSHORE	Offshore ocean to depths of 80 feet
LITTORAL	Nearshore ocean to depths of 40 feet (within the active littoral zone)
ML	Regular dredging of Moss Landing harbor occurs - frequency and quantity plus other sediment characteristics to be determined.
MCI	Monterey Bay dredging to occur in 2010. Sediment should be the same as in 2004 dredging episode. See dredge results for details.
MCO	Monterey County
CAL5	Caltrans District 5
SAL	City of Salinas
SCH	Santa Cruz Harbor District
WAT	City of Watsonville
HOL	City of Hollister
ES WSHED	Elkhorn Slough Watershed

2.3.1 Caltrans

A number of upcoming large scale roadway projects have been identified in Monterey County but it is not yet known how much sediment may result from these activities. Contact has been made with ongoing project managers in the area and the hope is to identify which of the larger projects, such as the US 101 Prunedale Improvement Project and the Salinas Interchange Project just north of the City of Salinas, will produce surplus sediment suited to placement at the Parsons Complex. Maintenance projects may also be a transportation sector sediment source.

2.3.2 County Land

Monterey County Water Resources Agency: It is assumed that the Water Agency possesses nuisance fill material from sedimentation on water storage areas, but repeated attempts to contact the Agency were fruitless. It is worth continuing to research available sediment through this Agency, however, in the case that periodic sources may exist.

Monterey County Mosquito Abatement District: This agency indicates potential future opportunities exist to make sediment available. A new excavator with a 50-foot reach was recently purchased by the District for excavation. Excavation projects are generally smaller in scale and involve ditches and ponds. Agency staff have not yet compiled specifics such as soil type or quantities but will share this information at a later point.

2.3.3 City Areas

Salinas: The Maintenance Services Department at the City of the Salinas has indicated a strong interest in assisting with sediment provision for the restoration project. Three sites, Gabilan Creek, Carr Lake Detention Basin and Manoboa Detention Basin are dredged of silt sediment annually. The quantity of material resulting from these dredging operations is yet to be determined.

Watsonville: This City has also expressed interest in assisting with sediment provision and most recently indicated that sediment would be available in the near future. Details on the type of sediment and window of availability are not yet available.

Hollister: The City of Hollister City Engineer indicated that a contractor is tasked with managing construction of a wastewater treatment plant for the city. Contact was made with the contractor and further research needs to be made directly with the City of Hollister.

2.3.4 Developer Activities

Assured Aggregates, a subdivision of the Don Chapin Company, indicated they will be involved in a project at Marina expected to produce 1.5 to 2 million tons of sandy material over the next 5 to 7 years. They indicated that a percentage, possibly a third, of this material may be available for use as fill and will be offered at a discounted rate. More specifics will be provided.

2.4 *Marine Sources Within the Region*

The ocean floor within Monterey Bay is a source of a practically infinite quantity of sediment for Parsons Slough. Specific sources are identified in local harbors, in the ocean offshore of Elkhorn Slough, and the nearshore zone near Moss Landing.

2.4.1 Moss Landing Harbor

The Moss Landing Harbor District has indicated strong interest in participating in the wetland restoration sediment sourcing efforts. At present the district conducts a 3-year maintenance dredging program in the Harbor with between 25,000 and 40,000 cy of dredge sediment produced per episode. Dredging also takes place after storm events. The gradation is a mix of sands, silts and clays. Additional gradation details are available from the district's geotechnical subcontractor. The next dredging episode is expected to take place in 2010.

2.4.2 Santa Cruz Harbor

The Santa Cruz Harbor District has expressed interest in making dredge sediment from their yearly dredge activities available for use at the project site. An estimated 10,000 - 20,000 cy of sediment is produced and is a mix of sands, silts and clays. The next dredging episode will take place in summer of 2008.

2.4.3 Monterey Harbor

The Monterey Harbor District (City of Monterey) supervises maintenance dredging on a bi- or tri-annual basis producing an estimated 75,000 cy per episode. The material is 95% medium grain sized sand. Test results from the last dredge project in 2004 are available for a compatibility analysis. Further analysis would be required to determine whether this material would be compatible with current placement site material chemistry.

2.4.4 Nearshore Ocean

The U.S. Army Corps of Engineers is considering a program to capture sand in the nearshore zone before it is lost to Monterey Submarine Canyon. Several options are under consideration, but they include pumping sand from the coast east to Elkhorn Slough and the Parsons Complex. The quantity of sand available is between 200,000 to 400,000 cy/yr and would be delivered either by pipeline or by barge or scow.

2.4.5 Offshore Ocean

The offshore zone near Monterey Canyon is a potential source of a large quantity of fine-grained sediment that would likely be compatible with Parsons soils. This sediment may be host to important and thriving benthic communities so dredging should consider potential environmental impacts. No program is considering dredging the offshore ocean for sediment, but this option is worth considering if funding were to become available and dredging was determined to be the best option for sediment addition at Parsons.

3.0 SEDIMENT ADDITION OPTIONS

Sediment addition options are possible components of restoration alternatives and are integrated into the planning and formulation of alternatives. As such, initial alternative concepts are described below for context, with sediment addition options subsequently addressed in more detail.

3.1 Restoration Alternatives

Wetland restoration alternatives for the Parsons Complex were developed by the joint effort of the Parsons Restoration Team (PRT) of the Tidal Wetland Project. Members of the PRT conceived of alternatives based on the project goals and objectives, information on existing conditions, and the feasibility of adding sediment. Three restoration alternatives were identified in addition to the No Project alternative. These alternatives will all be evaluated in detail in the Alternatives Analysis Report to be submitted in mid-2008, and they are only briefly presented here. The No Project Alternative is not addressed in this report. Concepts for these alternatives have not yet been prepared so no graphic renditions of them are available for this report.

These restoration alternatives, described in the following subsections, are:

- Alternative 1: Mute tides with control structure at/near UPRR Bridge;
- Alternative 2: Construct sill in Parsons Slough near UPRR Bridge; and
- Alternative 3: Measures that avoid construction at/near the UPRR Bridge.

3.1.1 Alternative 1: Mute The Tides In The Parsons Complex With A Water Control Structure At/Near The Union Pacific Railroad (UPRR) Bridge

Alternative 1 includes a water control structure to allow for the control of the high end of the tide range, but to not mute the low end of the range. While not muting the low end of the tide range, the structure would also function as a sill thereby preventing channel headcutting and facilitating retention of sediment within the system. The water control structure should be designed to limit the head differential between the inboard and outboard side of the UPRR levee to minimize impacts to the levee. It could also allow for relatively rapid development of vegetated marsh with the addition of sediment, and would allow for variety of sediment placement options including:

- Full filling of site, assuming sudden availability of sediment, and
- Partial/phased filling based on sediment availability.

There are concerns that existing muted-tidal systems perform poorly ecologically.

Specifically the list of concerns includes:

- There are already 18 muted areas in total in Elkhorn Slough;
- Some areas don't get enough water; others have too much water and little/no vegetation; and

- Wasson and Woolfolk (2007) have found lower biological diversity and generally (but not always) lower abundance in many organisms in muted versus unrestricted tidal marsh area.

Conversely, a fairly successful muted tidal habitat area was installed at Inner Bolsa Bay in Orange County by the Department of Fish and Game that possesses productive salt marsh habitat, and experiences low diversity but high abundance in fish species.

It should be noted that any structure installed at the railroad bridge would require the cooperation of UPRR.

3.1.2 Alternative 2: Construct A Sill In The Main Parsons Slough Channel Near The UPRR Bridge

Alternative 2 consists of a sill (a subtidal ridge) near the mouth of the Parsons Complex to limit/control Parsons' channel head-cutting and sediment export from the Parsons Complex, and therefore stop geomorphic disequilibrium. The sill should be composed of either rocks or concrete and be imbedded/founded sufficiently deep within the channel bed to not be undermined and not erode and fail, as could occur with earthern fill. In conjunction with a sill, water control structures could be installed inside the Parsons Complex to mute the tides in a smaller area. Internal muting options are:

- Mute at entrance to the Five Fingers area;
- Mute the 6th finger; and
- No muting.

If muting within the Complex is not done, the main effect of the sill would be to arrest degradation in the Parsons Complex. The sill's effect would not lead to restoration of marsh vegetation (unless fill were placed), and the site would be left as mainly mudflat of variable elevations. Placement of retained fill could create marsh habitat.

3.1.3 Alternative 3: Measures That Avoid Construction At/Near The UPRR Bridge

Alternative 3 consists of internal muting at the entrance to the Five Fingers area or at the 6th finger. Internal muting would avoid complications that could arise from opposition/lack of cooperation from the UPRR for treatment near/at the railroad bridge. Internal dikes would need to be composed of rock or concrete and be imbedded/founded sufficiently deep within the channel bed to not be undermined and not erode and fail (like earth fill could).

3.1.4 Sediment Addition Element of Alternatives

Sediment addition alternatives consist of prioritized placement options (including the best options and sequence for a phased approach) for sediment under muting and sill alternatives. The priority should be based on logistical feasibility, relative gain in marsh (e.g., compare acre of vegetated marsh gained per acre-foot of sediment added), impacts to existing habitat, cost, etc. Alternatives 1-3 are to be considered, with the highest priority sediment placement options included. As a note, sediment addition may not be the primary element of any Parsons Complex restoration project due to cost and a general lack of supply, and a project EIR may look at an extended sediment addition program, but assume that one area, at most, will be targeted for initial sediment additions.

3.2 Sediment Addition Options

Approximately 2.2 million cubic yards of sediment (calculated as in-place yardage) are required to raise the Parsons Complex from its existing low elevation to the elevation of mid- to high-marsh required to create vegetated salt marsh habitat, as determined in the Existing Conditions Report. This quantity is extremely large compared to the anticipated range of available sediment supply quantities described in Section 2 above, over a 20 or 30 year period. Consequently, sediment addition options should be examined in the context of what gains can be achieved strategically with a limited supply. Options for adding sediment to the Parsons Complex are systematically analyzed (scored and ranked) based on a variety of ranking factors. The Parsons Complex is a large area with varying conditions and needs, and a well-planned approach to sediment addition is needed to maximize the beneficial effects of adding fill, while minimizing or precluding adverse environmental impacts. A systematic ranking analysis of sediment addition can be achieved by determining the order, or priority of infilling of the wetland Complex. Once the priority for infilling is defined, a series of concept-level infilling projects are presented and analyzed that could occur under any alternative restoration scenario. These respective analyses are presented below.

3.2.1 Priority of Sediment Placement

The priority of sediment placement within the Parsons Complex was determined to serve as the basis for concept project designs. A ranking system was developed by evaluating the following factors and numerically determining the best location for sediment addition.

- Accessibility for construction;
- Availability of staging and stockpiling areas;
- Relative gain in vegetated salt marsh habitat per cubic yard of fill placed (e.g., compare acre of vegetated marsh gained per acre-foot of sediment added),
- Impacts to existing habitat;
- Proximity to potential sources;
- The ability to contain the fill and thus realize increases in elevation;
- Reduction in the overall tidal prism of the Complex; and
- Construction costs.

Other factors may become apparent that should be considered and can be added to this analysis as the project moves forward in concept design. The highest priority options and the sequence for a phased approach are presented herein.

3.2.1.1 Sites Considered for Sediment Addition

Sites within the Parsons Complex that would be suitable for receiving fill material were discussed with the entire PRT and the sites identified as being appropriate for evaluation are as follows (not in any particular order):

- The Five Fingers area;
- The 6th finger located west of the Five Fingers and adjacent to the UPRR rail line;

- The western/central portion of the Parsons Complex;
- Rookery Lagoon;
- Whistlestop Lagoon; and
- The remaining area of South Marsh.

Each of these sites is shown in Figure 5 and described below, and Table 2 shows some of the properties of each site and the approximate quantity of sediment needed for fill. Each site was considered because of its ability to produce project benefits from receiving fill, and also because each site is located along the perimeter of the Parsons Complex and accessible by land-based deliveries and equipment. For restoration using sediment infill, the Parsons Complex benefits from its planform consisting of multiple elongated segments (the fingers and other areas) with extensive upland edge length that provides greater access from much of the perimeter along its west and east boundaries. In addition, the UPRR rail line provides an opportunity for delivery. While sediment may be delivered through the Estuary waterways by water-based equipment, it is anticipated that significant quantities of material will be delivered by trucks that are the most typical mode of transport at this time for dry sediments.

Five Fingers

The Five Fingers area is appropriate to consider for sediment infill because it is large and relative low-lying, and thus contributes a significant portion to the tidal prism of the Parsons Complex (approximately 40% as determined by examining the topography/bathymetry of the site). In addition, sediment is typically placed in wetland areas behind containment dikes to retain the sediment in place and reduce its dispersion from the site by currents. The configuration of this area into several isolated "fingers" renders it suitable for isolated fill projects over time and space. Each finger can be diked off anywhere along its length, or near its base (connection to the larger Parsons Complex), and filled with sediment behind the containment dike to achieve the desired higher elevation. Fill can occur incrementally within each finger, and/or finger-by-finger to fill this area progressively over time and realize increased salt marsh habitat and decreased tidal prism. Access to the water areas at this site is a challenge, and it would take substantial fill to elevate this area sufficiently to form vegetated salt marsh habitat.

The 6th Finger

The 6th finger is another similar linear-oriented slough arm that is positioned and configured in such a way that sediment infilling is feasible. Like the other five fingers located to the east, the 6th finger is long and narrow and can be diked off along its length or near its base, and filled with sediment behind the dike to achieve the desire outcome. Fill can occur incrementally within this finger to fill it over time progressively and increase salt marsh habitat area. The 6th finger is higher in elevation (large areas at +2 feet NAVD and smaller areas at +1 feet NAVD) than the Five Fingers (mainly at 0 to +1 feet NAVD), and will therefore result in generation of vegetated salt marsh habitat from the addition of less fill than will be needed at the Five Fingers. Conversely, sediment infilling at the 6th finger will result in less reduction to the tidal prism than would infilling of the Five Fingers owing to its higher existing elevation. The 6th finger represents 5% of the tidal prism of the Parsons Complex. However, as with all other options with diking, it would achieve the project benefit of reducing further marsh loss behind a dike as the dike would constrain tidal prism. Access to the 6th finger is also a challenge, but it lends itself to access by both truck and rail.

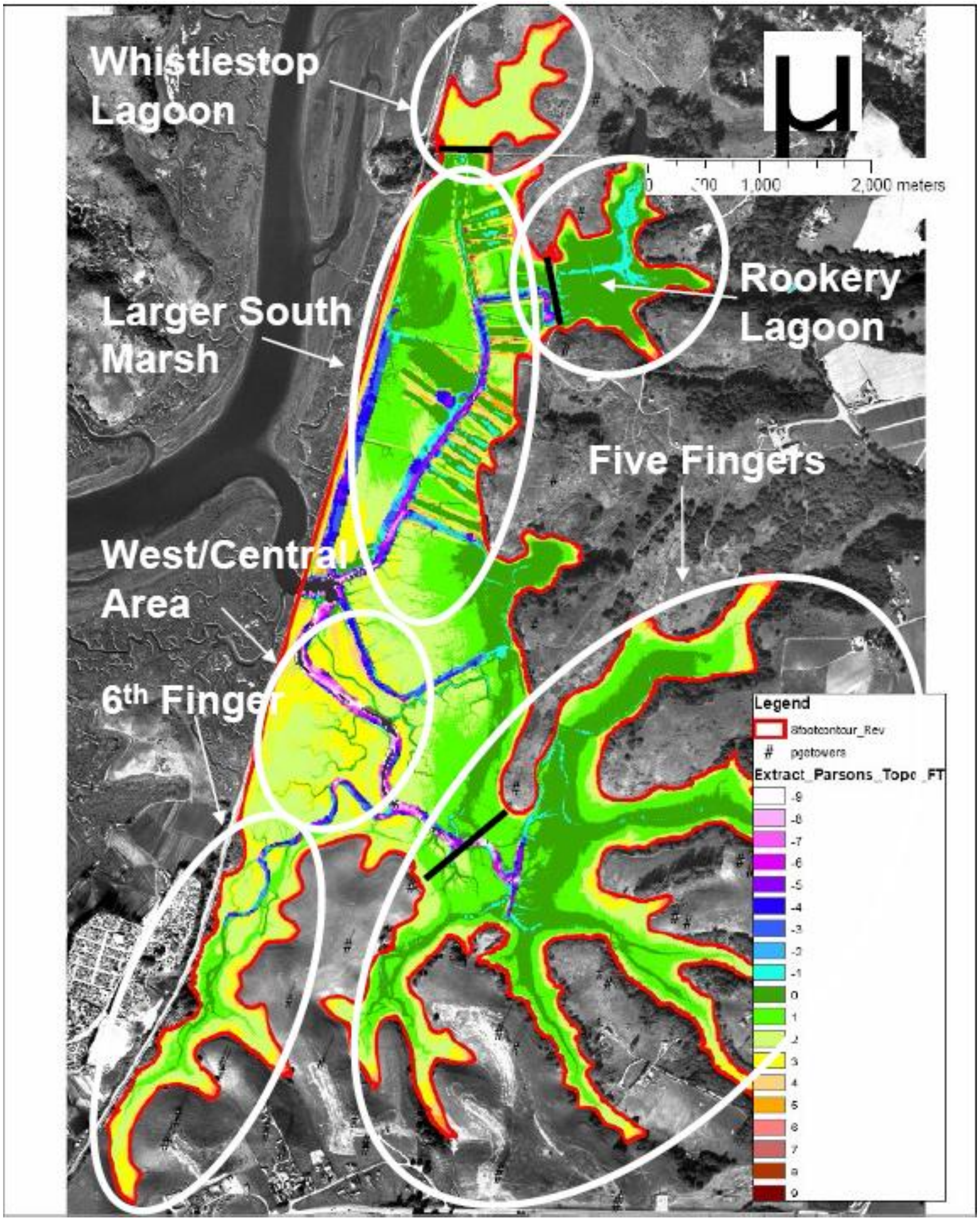

Figure 5 – Areas for Sediment Addition

Table 2. Parsons Complex Sediment Addition Sites and Characteristics

PARSONS COMPLEX SEDIMENT ADDITION SITES AND CHARACTERISTICS						
LOCATIONS	AREA (ACRES)	% OF PARSONS SIURFACE AREA	APPROXIMATE TIDAL PRISM (CUBIC FEET, OR CF)	% OF PARSONS TIDAL PRISM	APPROXIMATE FILL QUANTITY NEEDED TO RISE TO SALT MARSH ELEVATION (CUBIC YARDS, OR CY))	NEW HABITAT AREA CREATED PER CY OF FILL VOLUME ADDED (SF/CY)
CENTRAL/WEST MARSH SOUTH OF THE MAIN CHANNEL	44	10%	3,149,784	4%	69,995	27
FIVE FINGERS	142	31%	30,839,653	39%	1,142,209	5
6TH FINGER	33	7%	4,322,359	5%	96,052	15
LARGER SOUTH MARSH AREA	198	43%	34,426,880	43%	765,042	11
WHISTLESTOP LAGOON	20	4%	1,291,008	2%	28,689	30
ROOKERY LAGOON	25	5%	5,345,580	7%	118,791	9
TOTALS	460	100%	79,375,264	100%	2,220,778	Not Applicable

Western/Central Portion of the Parsons Complex

The central/western portion of the Parsons Complex, south of the main interior southern slough channel, is a relatively higher marsh area near the UPRR rail line. This central/west marsh area is higher in elevation than either of the two areas previously discussed, with some areas lying at +3 feet NAVD and large areas lying at +2 feet NAVD. As such, less material would need to be added to this site to create vegetated salt marsh areas as compared to the slough fingers. Conversely, addition of material at this site will lead to less reduction in tidal prism due to the sites relatively high elevation. The central/west area of Parsons represents approximately 4% of the tidal prism of the entire Complex. Access to this site is exclusively by rail, unless temporary roads are installed in the marsh for truck access.

Rookery Lagoon

Rookery Lagoon is a site that presents the advantages of already possessing a containment dike along its downstream side and being accessible to construction equipment with a staging area nearby. It also contributes approximately 7% to the tidal prism of the Parsons Complex within a small and contained area, so it could present a tangible benefit if partially filled. This site is relatively small in area and thus could serve as an initial pilot project area without affecting other areas of Parsons if results were not optimal.

Other Areas

Other areas of the Parsons Complex were not identified as being suited to initially receive sediment addition due to their inaccessibility for construction equipment, lack of tidal prism influence, and/or environmental sensitivity. Some of these areas may become more suitable over time under certain restoration alternative conditions, but are not prioritized in this report.

Whistlestop Lagoon – Whistlestop Lagoon is not considered because it only represents approximately 2% of the tidal prism of Parsons Complex, and it is home to a clam bed and thereby used by otters as a food and loafing area.

Larger South Marsh Area - The northern/central portion of the lagoon called South Marsh is difficult to access and contains sensitive pickleweed islands, yet is may present opportunities in containing fill between islands. If the sill or weir restoration alternatives move forward and they more effectively contain sediment throughout the entire Complex, it may become feasible to place fill areas of the larger South Marsh. Examples are infilling between existing pickleweed islands and relying on them for partial containment as part of a trucking operation, and potentially having sediment delivered by rail and placed near the foot of the UPRR levee. The larger South Marsh area should remain in the range of sediment placement options. This area represents approximately 43% of the entire tidal prism of Parsons Complex and thus could be beneficial if eventually infilled.

3.2.1.2 Results of the Site Evaluation to Determine Priority

A method to evaluate the priority of sediment addition sites was developed based on the factors mentioned above. Relative scores were assigned for each factor considered at each site on an arbitrary range from 0 to 3, with a value of 0 indicating no or low benefit (bad) and a value of 3 indicating the greatest conceptual benefit (good). While other, more detailed methods may exist and be applied to other sites, this analysis method functions to roughly separate the sites out into a ranking and relative priority that is sufficient for this conceptual effort. This method was applied to other sites (Malibu Lagoon and Topanga Lagoon in Southern California) and proved to rank alternatives under consideration effectively.

The scoring matrix is shown in Table 3. The Table indicates that the priority ranking of sediment addition to the Parsons Complex is the following:

1. The Five Fingers and 6^{th} finger in a virtual tie;
2. Rookery Lagoon;
3. The Larger South Marsh Area; and
4. The Central/West Marsh South of the Main Channel.

The bases for these results are that the fingers all have reasonably good and generally equivalent constructability with the least adverse consequences and concerns. Between the Five Fingers and the 6^{th} Finger, the primary difference is that the slightly higher existing elevations in the 6^{th} Finger would yield more vegetated marsh per cubic yard of sediment placed. Since the sediment deficit, 2.2 million cubic yards, is so great compared to the anticipated available supply, sediment addition may be most effective if geared toward gaining vegetated marsh while providing an equivalent tidal prism reduction benefit (which will be small in all cases due to small available supply). This priority of sediment additions is shown in Figure 6. It is recommended that future sediment addition to the Parsons Complex be done in this order, with the possible exception of an initial pilot project discussed below.

The rationale for this ranking is as follows.

1. The Five Fingers is a significant contributor (39% of the volume) to the tidal prism. Filling portions of it would address that problem and benefit the entire Elkhorn hydraulic system. It adds a modest amount of new marsh per fill quantity added (5 square feet per each cubic yard, or 5 sf/cy). This site provides a variety of potential access ways and is mainly within ownership of the ESNERR and therefore may not require permission of other landowners, including the UPRR, to conduct an operation. Containment of sediment is highly feasible due to the site's configuration of funneling through a relatively narrow opening at the "base" of the "hand." Sufficient space exists near the water to allow establishment of numerous equipment working areas. Although environmentally sensitive, effects of fill operations are not necessarily significant and the site can experience disturbance. A source of sediment from scraping adjacent hillsides was initially considered, but due to the potentially significant environmental impacts that could occur from that type of operation this source has been eliminated from consideration.

Table 3. Preliminary Relative Scoring Of Fill Sites For Various Considerations

PRELIMINARY RELATIVE SCORING OF FILL SITES FOR VARIOUS CONSIDERATIONS										
LOCATIONS	ACCESSIBILITY	STOCKPILE/STAGING	QUANTITY REQUIRED TO GAIN MARSH (CY/SF)	LACK OF ADVERSE IMPACTS TO HABITAT	PROXIMITY TO POTENTIAL SOURCES	ABILITY TO CONTAIN FILL	TIDAL PRISM REDUCTION FOR PARSONS	PROBABLE CONSTRUCTION COST (LOW COST IS GOOD AND HIGH COST IS BAD)	TOTAL	RANKING BASED ON SCORE
CENTRAL/WEST MARSH SOUTH OF THE MAIN CHANNEL	1	1.5	3	3	1	1	1	1	12.5	**5**
FIVE FINGERS	1.5	3	1	2	3	3	3	2	18.5	**1**
6TH FINGER	2	2	2	3	3	3	1	2	18	**2**
LARGER SOUTH MARSH AREA	1.5	2	1	1	2	1.5	3	1	13	**4**
WHISTLESTOP LAGOON	3	3	3	0	1	3	0	3	16	**Not Ranked**
ROOKERY LAGOON	2.5	3	1	1	1	3	1	3	15.5	**3**

Notes: Values represent the relative range of benefits, from 0 representing low benefit to 3 representing high benefit.
Whistlestop Lagoon is considered infeasible due to overall lack of benefit and high uacceptable impacts and is therefore not ranked at this time.
Lack of Adverse Impacts to Habitat was determined based on the judgment of the project consulting biologist.
The Five Fingers and 6th finger are considered equal as their scores are separated by less than 1 point.

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2. The 6th finger does not contribute significantly to the overall system tidal prism (5% of the total volume) and infilling would not tangibly benefit the entire Elkhorn hydraulic system. A fairly high ratio of habitat area gain per sediment volume added exists (15 sf/cy). This site provides more restricted potential access ways that are not entirely within ownership of the ESNERR and therefore requires permission of other landowners to conduct an operation. Sources of sediment do not exist immediately adjacent to this site, however it is located along the UPRR access line and near a local roadway, so a combined truck/rail operation may be feasible. Containment of sediment is highly feasible due to the site's long and narrow configuration. Limited space exists near the water to allow establishment of equipment working areas. This area may be potentially less environmentally sensitive than other areas and effects of fill operations may not be significant for long-term habitat impacts.

3. Rookery Lagoon is a modest contributor to the tidal prism for its area (7% of the total volume). It also produces only a modest area of marsh per sediment volume added (9 sf/cy). This site provides an established access way and is entirely within ownership of the ESNERR and does not require permission of other landowners to conduct an operation. Sources of sediment exist in proximity to place at this site. A sediment containment dike already exists in the form of the west levee. Sufficient space exists near the water to allow establishment of a main equipment working area. This site is very environmentally sensitive and may best serve as a small-scale pilot project site in one area, rather than as a large-scale fill opportunity over the entire site. Any fill efforts should be done outside the breeding season.

4. The larger South Marsh area is the most significant contributor to the tidal prism (43% of the total volume) and filling portions of it would benefit the entire Elkhorn hydraulic system. It also yields a fairly high ratio of creation of new vegetated marsh area per quantity of fill added (11 sf/cy). This site provides various access ways from both the west and east. Access from the east is mainly within ownership of the ESNERR and therefore may not require permission of other landowners. Access from the west is along the UPRR line and requires their permission to conduct an operation. Sources of sediment may be immediately adjacent to the east side, and since it is located along the UPRR access line a combined truck/rail operation may be feasible. Containment of sediment is feasible if done using existing ridges as dikes. Sufficient space exists along the east side near the water to allow establishment of numerous equipment working areas. This site is environmentally sensitive and effects of fill operations could be significant if not done with careful planning and great care.

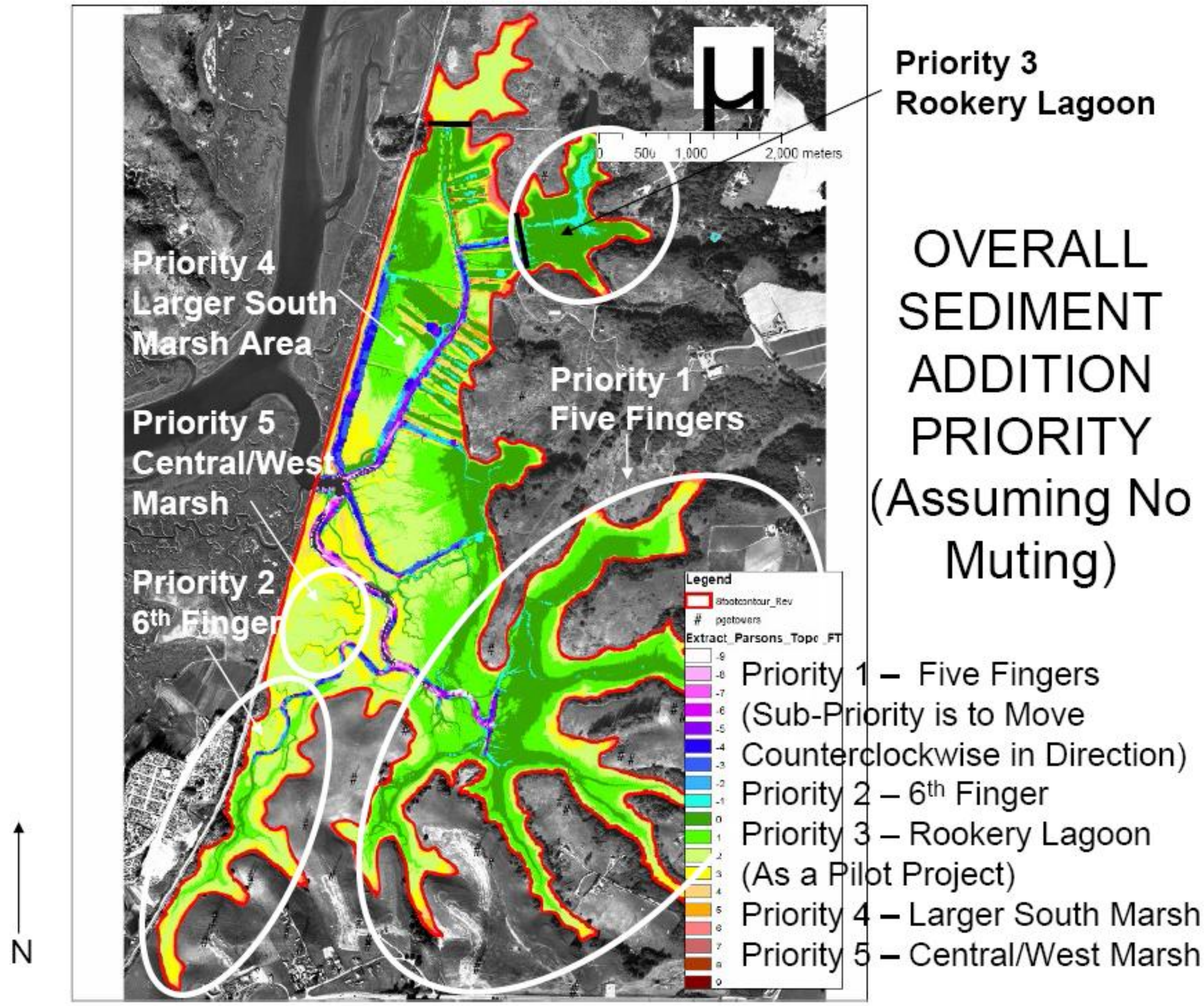

Figure 6 – Overall Sediment Addition Priority

5. The central/west marsh south of the main channel does not contribute significantly to the overall system tidal prism (4% of the total volume) and infilling would not tangibly benefit the entire Elkhorn hydraulic system. A very high ratio of habitat area gain per sediment volume added exists at 27 sf/cy. This site is much more restricted in potential access ways and requires permission of other landowners, specifically the UPRR, to conduct an operation. This site is located along the UPRR access line and near a local roadway, so a combined truck/rail operation may be feasible. Containment of sediment is not feasible due to its broad and flat configuration, rendering it exposed to tidal currents, although it is protected from wind waves more than most other areas in the marsh. Virtually no space exists near the water to allow establishment of equipment working areas. This area may be potentially less environmentally sensitive than other areas and effects of fill operations may not be significant for long-term habitat impacts.

3.2.1.3 Pilot Project

As a first effort, a pilot project is recommended for consideration at an area within a site such as Rookery Lagoon on a small scale to test the procedure of delivering sediment, to document environmental effects, and to monitor the evolution of habitat at the fill site. This effort may help the ESNERR to understand whether they wish to continue trucking and become involved in larger operations. If this proves too disturbing or unproductive for wetland creation, the ESNERR can consider rail transport and possibly other procedures to improve marsh production such as soil amendments.

Although Rookery Lagoon scored lower than both the 6^{th} finger and Five Fingers, it offers advantages over those sites for a pilot. The main advantage of initially filling a portion of Rookery Lagoon is that the site is already physically protected with a dike, thus enabling fill to be placed within some portion of the site without having to install a containment dike as part of the project and risking associated complications (difficult to build in the wet, dike failure, etc.). In addition, access over ESNERR property is available as well as a nearby staging area for equipment and material to facilitate construction efforts. Finally, this site possesses a relatively large tidal prism for its relatively small surface area, and could cause reduction in the prism with minimal infilling of sediment. Details of the pilot should be worked out subsequent to this effort, as this report presents the broader approach to filling Parsons Complex.

3.2.2 Methods of Sediment Placement

Construction methods for sediment placement vary, and include those for material delivered in a dry condition and for material delivered in a wet condition, and for material placement in the dry and in water. For all materials, it is suggested to not compact the fill once placed to allow for a more natural type of settlement in the wet tidally-influenced conditions. Compaction could lead to undesirable conditions for vegetative growth. More natural settling is assumed to provide for conditions more suitable for native plant establishment.

3.2.2.1 Material Delivered in the Dry

Material is delivered in the dry by trucking or rail. Conventional delivery by truck and/or train can be supplemented with an on-site “batch plant” where the dry sediment could be fluidized and transformed into a slurry that could be pumped throughout the Complex. Each transport mode is described below.

Trucking

The most common type of transportation for fill material from upland to the site will be by truck. Trucking is the conventional transport mode for the upland construction industry. Costs for trucking are lowest when the number of times the material is handled is minimized, so this discussion emphasizes "single- or double-handling" of material since the needed quantity of sediment addition is relatively high for this project, Material is typically loaded into trucks capable of carrying from 10 cubic yards for a standard rear-dump truck, 14 cubic yards for a twin-trailer belly dump truck, to 20 cubic yards for a "super 10" rear dump truck (the longest bed of any on-road single-trailer truck used for transporting earthen material) and a twin-trailer rear dump truck arrangement. The total number of truck trips to deliver the 2.2 million cubic yards of sediment needed to raise the Parsons Complex up to elevation +5 feet NAVD for establishment of vegetated salt marsh habitat over approximately one-half to two-thirds of the site (arbitrarily determined, but representative of other salt marshes in California) is between 110,000 and 220,000 round trips, depending on the size of the truck. Needless to say, this level of trucking causes quite a disturbance to traffic, infrastructure, the environment, and public safety.

Generally, the considerations most important for sediment addition at a site are direct access by trucks and earthmoving equipment and available working/staging area. Each placement area at the Parsons Complex presents unique opportunities and challenges for accessing the site and placing material. An interim land-based delivery system may need to be installed that serves to provide the access and working/staging areas needed to accommodate deliveries from upland. A general upland construction scenario is presented below, including specific comments for each priority infill area. The actual approach may vary, but this description provides insight as to the effort that may be required. This description is only to present information for decision-making, and is not necessarily a recommended approach.

For this description it is assumed that material will eventually be trucked to the vicinity of Parsons Complex and be delivered either on Elkhorn Road or Dolan Road. Trucks need to be able to gain close access to their ultimate dump site(s), so it will be necessary to provide temporary truck routes to as close to the edge of the wetland as possible to minimize re-handling of the sediment (and associated costs). Temporary haul roads should be approximately 30 feet wide to allow traffic in two directions. A working/staging area should be positioned immediately adjacent to where sediment will be placed in the wetland. This working area should be one that supports a piece of equipment such as a long-arm backhoe or a crane that can reach out over the wetland and place a bucket-full of sediment in the desired location. Working areas should be approximately 10,000 square feet (one-quarter acre) in area to support the operation.

The optimum scenario would consist of a truck haul ingress route directly to the working area at the wetland shore, and a separate truck egress route directly back to the nearest road. The working area would be large enough that trucks can dump their loads on it, a bulldozer can then push the material dropped from the trucks into a large stockpile, and a crane or long-arm backhoe can scoop up bucket-fulls of sediment for placement in the wetland. Ideally, the working area can be moved along the wetland shore to enable progressive placement as needed within the wetlands.

The best possible layout for the operation from a construction standpoint would be to have a temporary haul road system installed along the upland perimeter of as much of the Parsons Complex as possible (considering constraints of habitat and topography), with sufficient working areas spaced as needed to provide for nearly complete coverage by material placement. However, resource agencies recommend that haul route construction be minimized rather than maximized due to loss of upland habitat, spread of invasive plants, and roadkill of wildlife that would be associated with construction and use of an extensive haul road system. Therefore a balance will have to be achieved for access for hauling and protection of the environment. Specific scenarios for land-based sediment addition according to the priority determined in this report are described below.

Rail

A second mode of upland sediment delivery to a site is by train. Rail transport of sediment along the UPRR line could deliver large quantities of sediment to the site. Rail cars that haul aggregate are equipped with either doors that open under the bottom of the car, or the cars tip and allow material to be emptied from the car. A system of conveyance has to be installed to move the material from either under the rail car or from next to the tracks to the desired stockpile or placement site. A similar system was used for delivery of 75,000 cubic yards of sand to Seal Beach in southern California in 1997/98 that worked successfully to nourish that site. Figure 7 shows material loaded into rail cars and Figure 8 shows the offloading conveyance infrastructure needed to at the offloading end (track in the foreground, conveyor belt under track, and scraper in the background to receive a load) as examples of material moved by train.

Permission of the UPRR is required for this operation. Material costs for delivery depend on rail costs and can exceed costs for trucking. Sediment delivery costs by rail for the Seal Beach project were approximately 20% higher than the costs would have been to deliver the material by truck. Some of the cost increase is due to the need to install a conveyor system from the rail car drop site to an earthwork stockpile, as well as trucking the material first to a yard and loading it on to trains. The advantage of rail for that project was the large quantity delivered over a short time and the lack of impact to traffic, air quality, and public safety from rail compared to trucking.

Batch Plant and Slurry Conveyance System

If environmental impacts of an upland type of sediment delivery option are too great, an additional option for sediment delivery to the marsh is to convert the sediment into a slurry and pump it through the Complex. A batch plant is a working site where aggregate fill is processed and converted into another form for transfer within a site. A conceptual batch plant and slurry conveyance system could be established at the Parsons Complex by identifying a suitable site for sediment delivery, stockpiling, fluidization, and conveyance.

Candidate sites would be accessible to the local road network and located in proximity to destinations of the slurry. Sites would likely consist of a pad for sediment drop-off, an area for sediment stockpiling, and a large water-filled pit to fluidize the sediment. It is assumed that each area within the Parsons Complex for sediment additions possesses sufficient area for a batch plant, but specific sites are not identified herein. Equipment would include a submersible pump within the pit to pump the slurry into the Complex and a network of discharge lines for conveyance. A water return line would be required to keep the pit filled with water from the wetland.

This slurry conveyance process is environmentally more sensitive than large scale trucking and should be considered. However, the cost to handle the sediment a second time (carried/pushed to the stockpile) or third time (carried/pushed to the pit), plus the cost of the pumping and conveyance system may be high when added to the original trucking cost.

Specific Sites for Sediment Additions

The 6^{th} Finger – The 6^{th} Finger presents the opportunity to possibly access the site off Dolan Road near the junk yard, yet poses the difficulty of having to cross the UPRR rail line throughout the infill as it lies between the finger and the road. Figure 9 shows one possible scenario of sediment delivery by truck to the 6^{th} finger and the westernmost finger of the Five Fingers. Once trucks reach the northern end of the Dolan Road northern spur adjacent to the junk yard, they may need to cross over the UPRR rail line over a temporary construction crossing and access a haul road along the west shore of the 6^{th} finger. The haul route could extend along the entire west shore of the 6^{th} Finger, with working areas located as appropriate considering topographic and habitat constraints. Several natural protrusions exist along the 6^{th} finger west shore that could possibly be used as working areas, and new ones could be constructed using some of the fill material delivered from off-site. At the north terminus of the Dolan Road north spur, the haul road would have to cross the UPRR rail line again to provide a full loop for trucking. Operating two rail line crossings during trucking operations would require permission from the UPRR and use of traffic control flagmen to control truck traffic around the train schedule.

The east shore of the 6^{th} Finger could be accessed off Dolan Road through land owned by the ESNERR using access roads to some PG&E facilities. Temporary haul roads would need to be extended from the existing access roads to the edge of the wetland, and working areas would need to be installed as appropriate. The entire east shore of the 6^{th} finger is grazed, and contains many native coastal prairie wildflowers only visible seasonally. Although sensitive, it presents an opportunity to extend the road to some portions of the shore and establish working areas.

A containment dike should be installed as the first component needed for infilling of the 6^{th} finger. The dike can be constructed by accessing both the west and east shores of the finger near the northern terminus of the north Dolan Road spur, and placing loads of material into the wetland by reaching with a crane or long-arm backhoe. To extend the dike all the way across the channel, the backhoe would have to drive on top of the dike as it is formed to place fill beyond the reach from shore. The elevation of the containment dike would be above the tides, possibly at +8 feet relative to NAVD. The dike would have to be formed and compacted using bulldozers and other equipment. Drainage pipes would need to be installed through the dike to allow tides to enter and then drain from the fingers in a controlled manner, and to allow preservation of habitat conditions and water quality while still retaining the fill. The size of the pipes is to be determined based on hydraulic calculations.

Figure 7 – Sediment Loaded onto a Rail Car for Train Transport

Figure 8 – Sediment Offloading Site for a Rail System

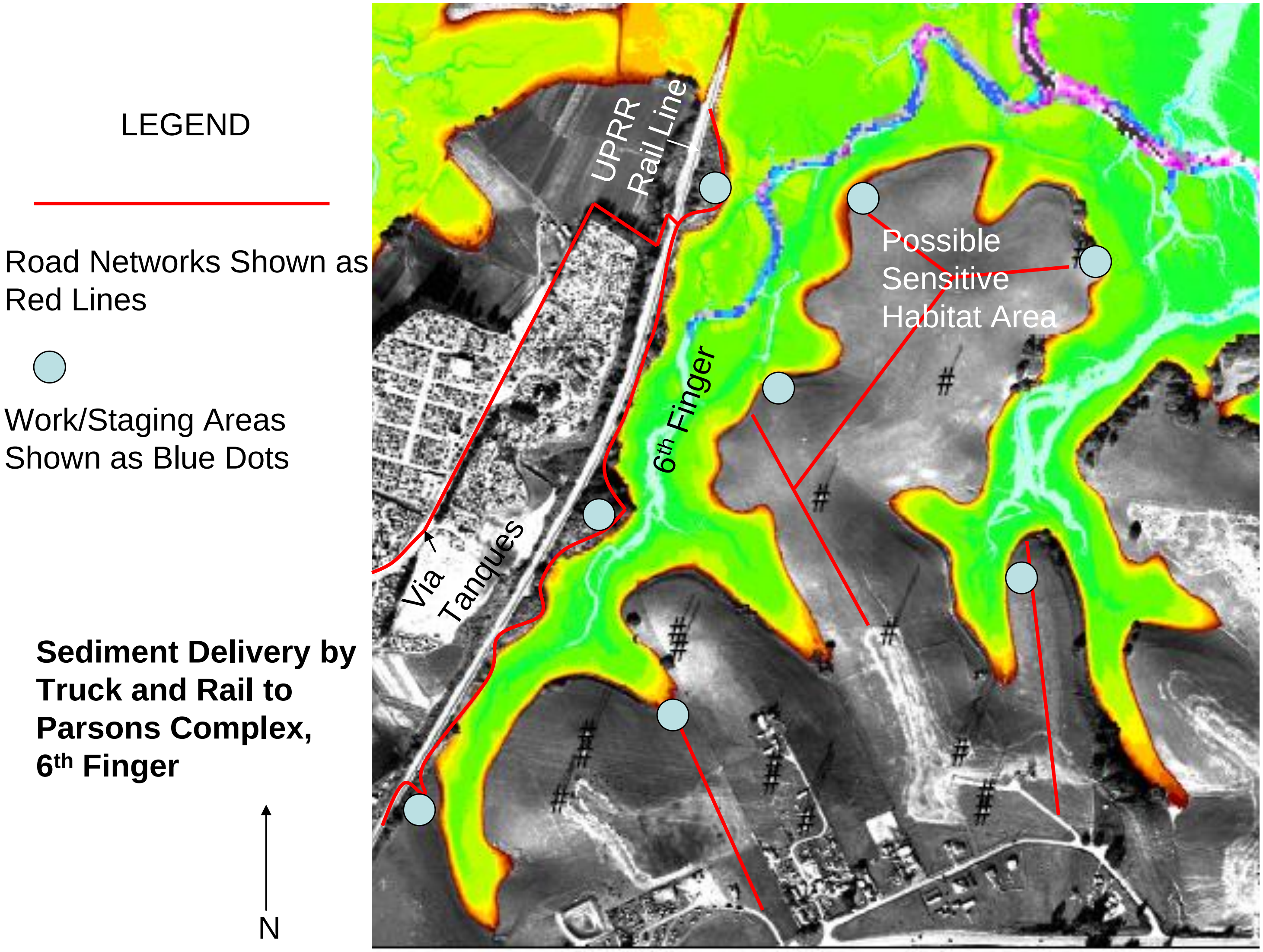

Figure 9 - Sediment Delivery by Truck and Rail to Parsons Complex, 6th Finger

The construction standards for the containment dike would only be as stringent as required to retain its structural integrity under conditions that would potentially erode the infill within the wetland, and would not be as strict as FEMA flood levees. Therefore the effort required to construct the dike could be minimal as opposed to extensive, and the material used to construct the dike could be the same fill material brought to the site to raise the wetland. The process to erect a containment dike is similar at each wetland fill location and will not be described in detail in the construction methods section for other areas of the Parsons Complex.

Once the containment dike is installed, sediment can be added to the marsh surface in layers, or lifts. However, assuming that dewatering of the receiving marsh will not occur during construction, controlling the fill at the placement location will be difficult. It may be that the fill is placed at the general target location and be allowed to disperse under tidal current conditions throughout the area of the receiving marsh behind the containment dike. Desired marsh elevations can be achieved gradually over time using this approach. Depending on the quantity of sediment available to use as fill, many successive placements may be required to gain the desired effect. The method of filling using upland material will be similar at each location within the Parsons Complex. Depending on the alternative chosen for restoration, the dike can either be left in place to control/mute tides, or breached with the earthmoving equipment at completion of the work to allow tides to fully exchange.

Equipment required to perform this work at all areas of the Parsons Complex will likely consist of the following:

- Haul trucks;
- Front end loaders;
- Backhoes;
- Cranes; and
- Bulldozers.

The number of pieces of equipment will vary and depend on the scale of the fill event.

<u>The Five Fingers</u> – Five Fingers offers the opportunity to obtain fill, and access and fill wetland sites from land owned primarily by the ESNERR for a mostly internal operation. This allows free access to working areas, and for creation of upland haul roads and working areas without permission from others, with the exception of appropriate permit agencies. Receiving fill from the region from on-road trucks similar to what was described for the 6th finger is described below.

Fill could be received and placed using material trucked in from outside the ESNERR property. A network of access roads could be installed along the ridgelines between the fingers to allow on-road trucks access to the sediment drop points, and to allow their return trip to either Dolan or Elkhorn Roads**.** Figure 10 shows one possible scenario of sediment delivery by truck to the Five Fingers from outside the ESNERR property. The off-road haul routes could extend along portions of the Five Fingers shore, with working areas located as appropriate considering topographic and habitat constraints. Working areas could be constructed using fill material delivered from off-site. The shore of the most southwestern finger (the thumb) is grazed but

LEGEND

Road Networks Shown as Red Lines

Work/Staging Areas Shown as Blue Dots

Sediment Delivery by Truck To the Parsons Complex, Five Fingers

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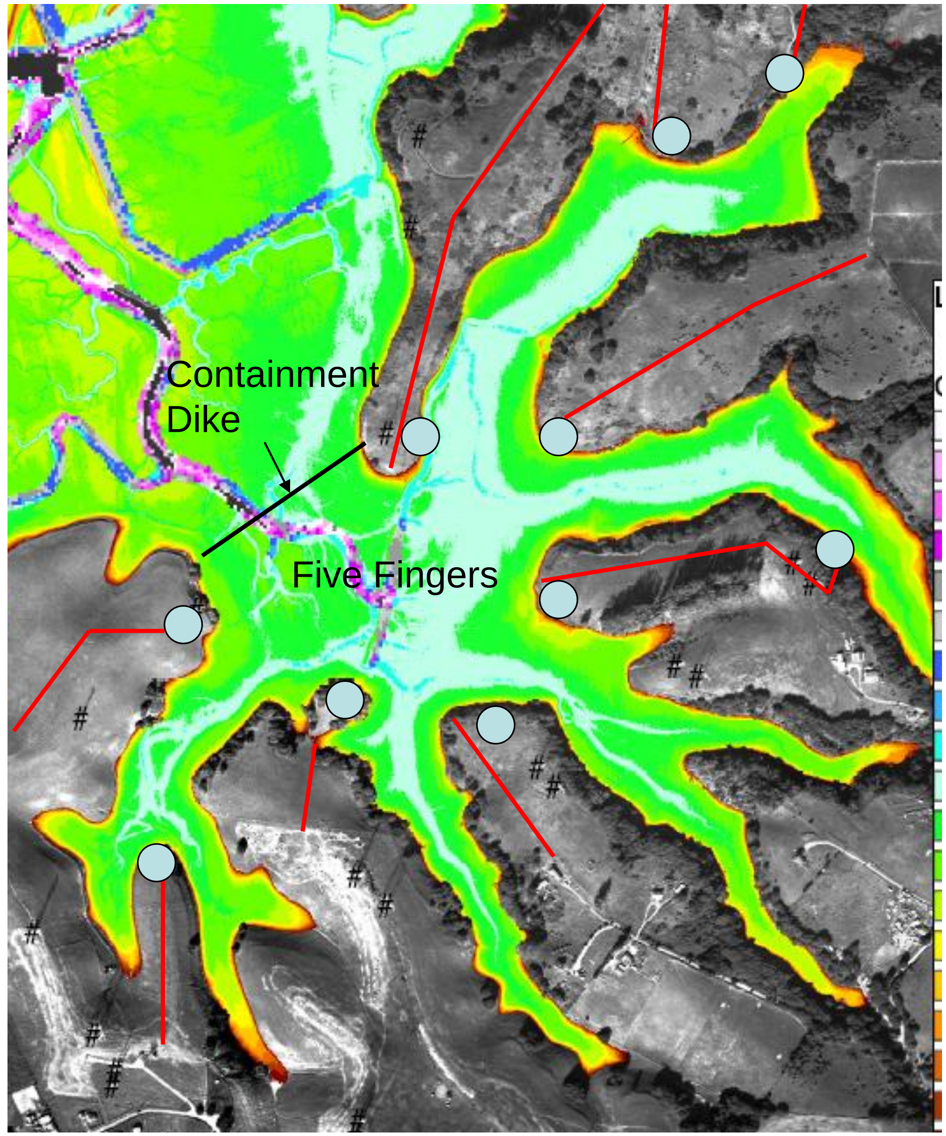

Figure 10 - Sediment Delivery by Truck to Parsons Complex, Five Fingers

contains sensitive grassland, yet presents an opportunity to extend the road along portions of the shore and establish working areas. However, the shores of all other fingers become progressively more vegetated, except where cleared by farming activities, and present more of a constraint to a shore-long haul road system. Areas of hemlock and coyote brush can be cleared for operations, but areas with oak trees cannot be cleared. These fingers may have to be filled from discreet working areas, and may have to rely more on tidal currents to disperse the fill throughout the wetland areas from the land-based placement sites.

As with all other fill sites, containment dikes should be installed at the base of each finger as the first component needed for infilling. The construction process for the dike is similar to that described above. Containment dikes can be built along any portion of the fingers that allow sufficient access from shore, and can be located to allow infilling wherever appropriate within the fingers. This report assumes the fingers will be diked-off at their bases to allow sediment infilling behind them and within the finger, and dispersion of the sediment throughout the finger over time by tides.

After diking, sediment can be added to the marsh surface using equipment with a long reach without dewatering of the receiving marsh. The fill should be placed at the general target location and be allowed to disperse under tidal current conditions throughout the area of the receiving marsh behind the containment dike. Desired marsh elevations can be achieved gradually over time using this approach. Depending on the quantity of sediment available to use as fill, many successive placements may be required to gain the desired effect.

Rookery Lagoon – Rookery Lagoon also offers the opportunity to obtain fill, and access and fill wetland sites as an internal operation for the ESNERR. This allows relatively unrestricted access to all working areas, and for extension of existing upland haul roads and creation of new working areas without permission from others, with the exception of jurisdictional permit agencies.

To receive fill from outside the ESNERR property, a network of access roads could be extended from an existing road north of the Rookery to allow on-road trucks access to the sediment drop points, and to allow their return trip to Elkhorn Road. Figure 11 shows one possible scenario of sediment delivery by truck to Rookery Lagoon from outside the ESNERR property. The off-road haul routes could extend to specific drop points, with working areas located as appropriate considering topographic and habitat constraints. Working areas could be constructed using fill material delivered from off-site. The only option for access to the shore is along two points at the northern shore of the Rookery as shown in the Figure. The ESNERR will have to operate using discreet working areas and placement sites, and have to rely on tidal currents to disperse the fill throughout the Rookery Lagoon from the placement sites.

A containment dike already exists at the mouth of Rookery Lagoon so no diking would be needed at that location, and no other dikes should be constructed as the site is fairly constrained by vegetation along the shore. Operations at this site should rely on dispersion of the sediment throughout Rookery Lagoon over time by tides.

After diking, sediment can be added to the Lagoon using equipment with a long reach with no dewatering of the Lagoon. The fill should be placed at the general target location and be allowed

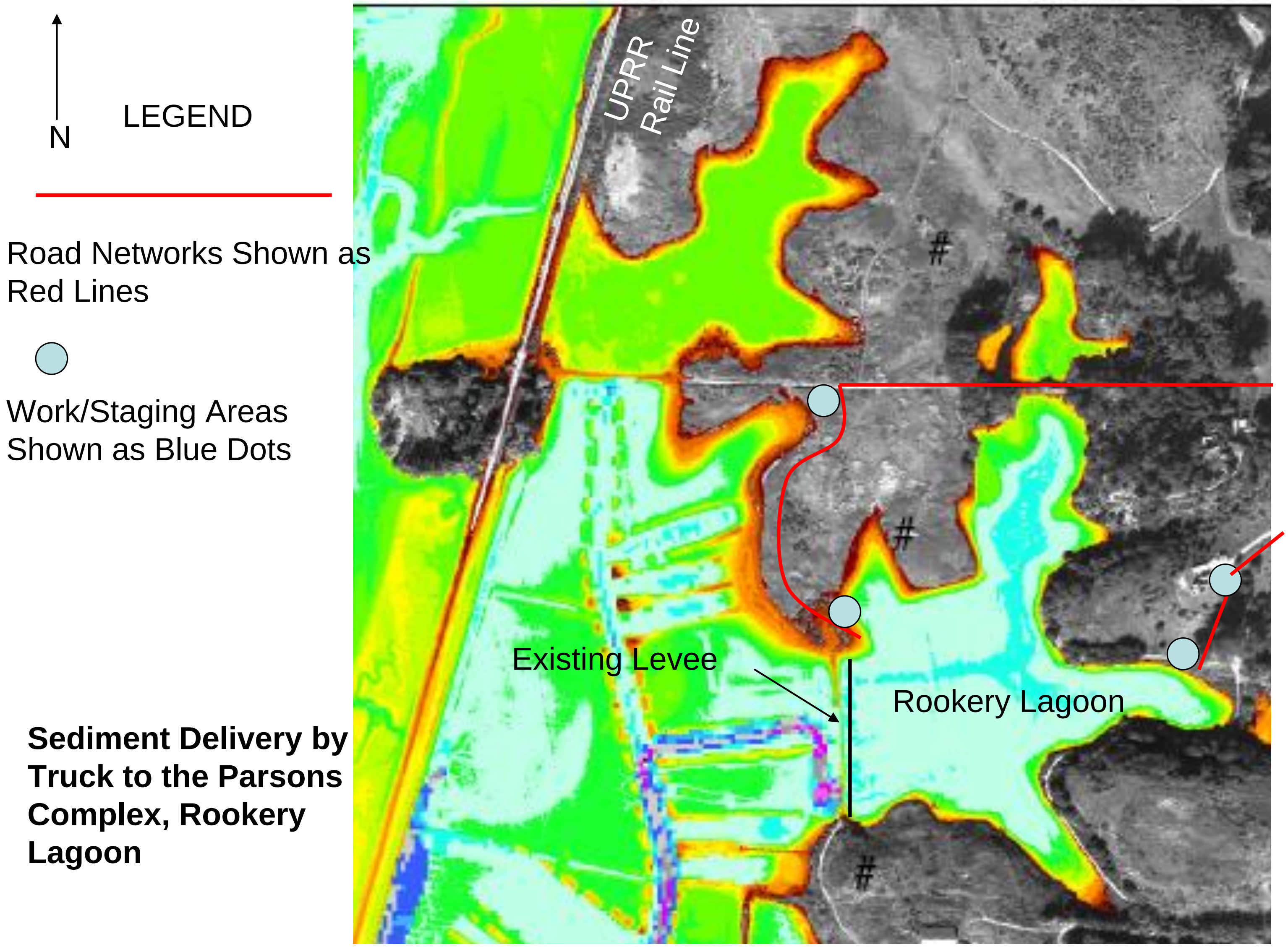

Figure 11 - Sediment Delivery by Truck and/or Scraper to Parsons Complex, Rookery Lagoon

to disperse under tidal current conditions throughout the Lagoon. Desired marsh elevations can be achieved gradually over time using this approach. Depending on the quantity of sediment available to use as fill, many successive placements may be required to gain the desired effect.

The Larger South Marsh Area – This area of the Parsons Complex should be able to receive material delivery by truck and/or the UPRR rail line. The approach for this site is essentially a hybrid of the operations needed for the previous three areas described in this section. It may be possible to truck fill in from outside the ESNERR on internal temporary haul roads. It may be necessary to utilize existing trails as temporary haul roads by expanding them, and to create temporary working pads along the eastern shore of South Marsh. Additionally, trains can transport material along the rail line and dump material along the east side of the UPRR line. All considerations of material delivery by rail discussed previously would apply to this situation as well.

Material placed within South Marsh may be able to be contained between islands that will provide some measure of protection from currents. This approach may be feasible along the east side of South Marsh where cranes may be able to reach into the marsh from shore. It may not be feasible to contain fill placed from the rail line using the islands as they are located too far from shore and equipment would not be able to reach that far. Sediment addition at many areas of South Marsh may have to be uncontained and dispersed by currents. Adding sediment to South Marsh may be best performed in conjunction with the alternatives of installing a weir at the UPRR Bridge of a sill near the bridge.

Figure 12 shows a possible combined scenario of trucking and transport by rail for marsh infilling. Equipment required to perform this work would include:

- Trucks and/or possible rail cars;
- Front end loaders;
- Bulldozers;
- Backhoes; and
- Cranes.

The number of pieces of equipment will depend on the scale of the operation.

The Central/West Marsh South of the Main Channel – This area of the Parsons Complex will have to rely on combined truck access and material delivery by rail. The closest road ends just south of the placement area allowing truck delivery to the far south end of this site. Also, in a combined truck/train operation, it may be possible to transfer the fill material to rail cars staged on a rail spur line off the main along Dolan Road at the southern perimeter of the power plant. These types of spur lines provide areas to stage and load rail cars prior to material transport by rail to the site. Permission from the UPRR and Pacific Gas & Electric (PG&E) would be required for this operation, along with coordination with their possible use of the spur rail line. Figure 13 shows the rail spur line and possible material transfer site.

LEGEND

Railroad Line and Truck Route Delivery Route Shown as Red Lines

Work/Staging Areas Shown as Blue Dots

Rail Car Dump Sites Shown as Arrows

Sediment Delivery by Truck and Rail to the Parsons Complex, Larger South Marsh Area

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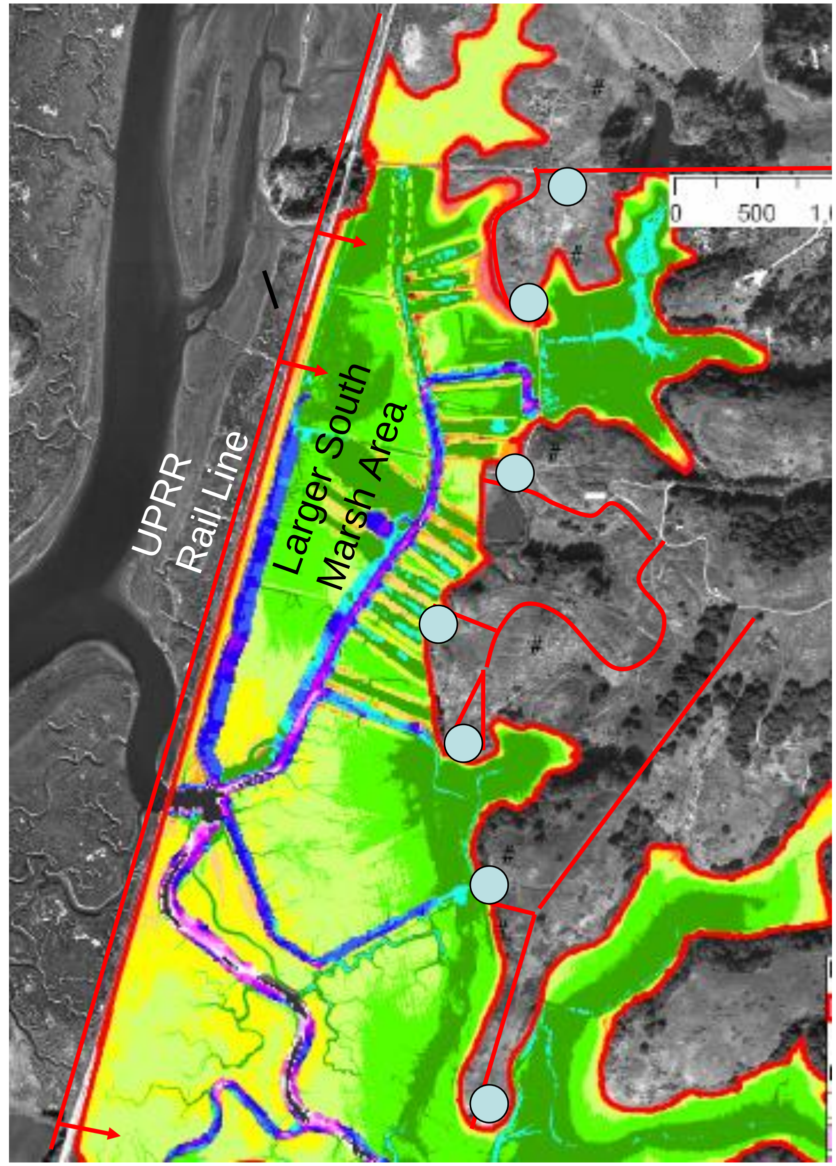

Figure 12 - Sediment Delivery by Rail to Parsons Complex, Larger South Marsh Area

Figure 13 – Rail Spur Line Location Relative to the Parsons Complex

Figure 14 shows a possible combined scenario of trucking and transport by rail for marsh infilling. Equipment required to perform this work would include:

- Trucks and/or rail cars;
- Front end loaders;
- Bulldozers;
- Backhoes; and
- Cranes.

As with all other sites, the number of pieces of equipment will depend on the scale of the fill operation.

Only one working area appears to be available based on lack of available space, and it could be located near the northern terminus of the road. At the north terminus of the north Dolan Road spur, trucks would either cross over the UPRR rail line over a temporary construction crossing and access a placement site along the west shore of the wetland, or drop their loads west of the rail line and drive away. Operating a rail line crossing during trucking deliveries would require permission from the UPRR and use of traffic control flagmen to control truck traffic around the train schedule.

Alternatively, trains could deliver sediment to the site. A system of conveyance could be installed to move the material from either under the rail car or from next to the tracks to the desired stockpile or placement site. Permission and cooperation of the UPRR is required for this operation, and timing of deliveries would be around the existing train schedule. Use of the rail spur line along Dolan Road could facilitate delivery from afar by truck for loading into rail cars, and specific site access with the material by rail.

Constructing a containment dike at this location would be very difficult and potentially not possible without significant effort, so it is assumed that fill would be placed at this site without containment. This alternative would only really be viable for an alternative that includes installing either a weir at or sill near the UPRR bridge. Like some of the other sites at Parsons, fill operations at this site should rely on dispersion of the sediment throughout the wetland over time by tides and not by use of equipment. The fill should be placed at the general target location and be allowed to disperse under tidal current conditions throughout the wetland. Desired marsh elevations can eventually be achieved gradually over time using this approach but may require a significant period of time.

3.2.2.2 Material Delivered in the Wet

Adding wet sediment to a marsh is most commonly done either by hydraulic pumping of a slurry shown in Figure 15, side-casting of a slurry (shown by PWA, 2007, in a previous presentation to the ESNERR), or by scooping wet sediment off of a barge or out of a scow (vessel storing sediment in its hull) with a clamshell dredge (crane and bucket). A scow could pass under the Highway 1 bridge but a high-profile tug boat could not, so the scow would have to be pulled by a low-profile vessel to access Ekhorn Slough. Aerial spraying of a slurry and scooping using

LEGEND

N

Railroad Line Delivery Route Shown as Red Line

Work/Staging Areas Shown as Blue Dots

Rail Car Dump Sites Shown as Arrows

Sediment Delivery by Rail to Parsons Complex, 6th Finger and Central/West Marsh South of the Main Channel

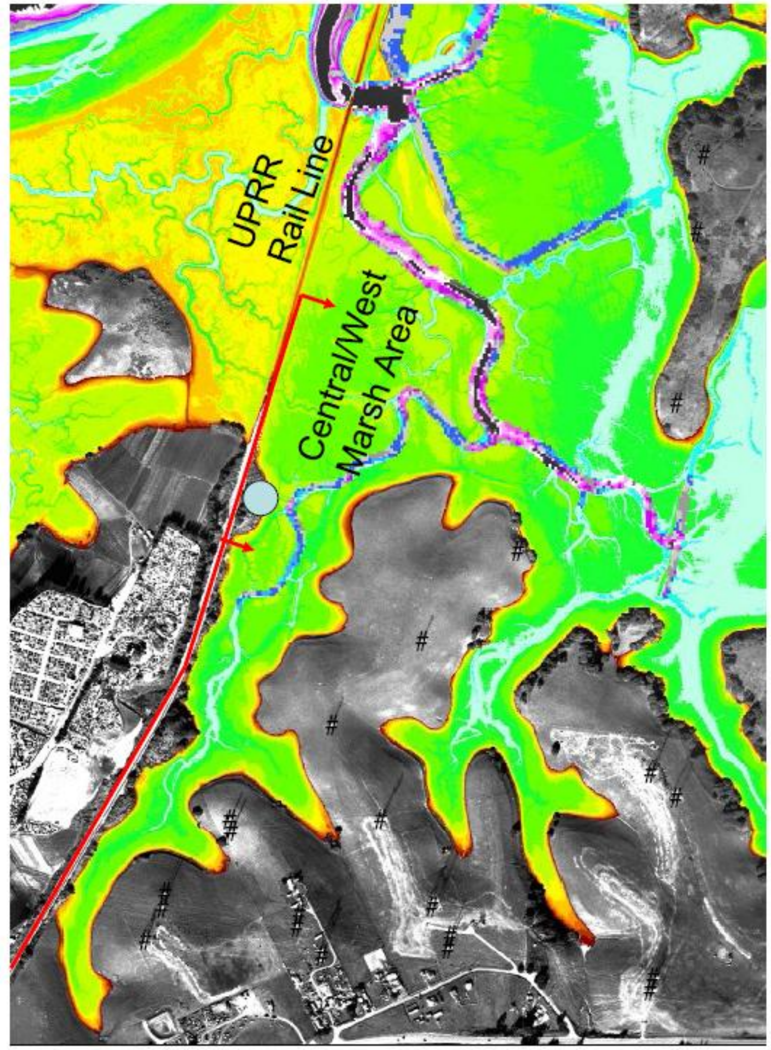

Figure 14 - Sediment Delivery by Rail to Parsons Complex, 6th Finger and Central/West Marsh South of the Main Channel

Figure 15 – Hydraulic Discharge Line Layout for Creating Landfill

clamshell dredge are infeasible scenarios at the Parsons Complex because they would occur from a barge or scow, and insufficient headroom exists under the UPRR Bridge to pass under it with this equipment (even at low tide).

Hydraulic pumping is a possible sediment delivery and placement method. The work could occur by mooring a scow downstream of the UPRR bridge and extending a hydraulic discharge line into the Parsons Complex. Figure 16 shows a potential lay-out of a discharge line system in the Complex. A system of discharge lines that extend into all areas of the Complex could be installed from one point of origin. The lines could be controlled manually with valves that direct the slurry through the appropriate line to the target destination. Once one target receives the needed quantity of material, the valve could be turned directing the slurry to the next target site, and this progressive filling of priority sites could occur until the sediment source is exhausted.

Sediment would be delivered from a marine source, such as Moss Landing Harbor, the nearshore ocean, the offshore ocean, Monterey Harbor, and Santa Cruz Harbor. Sediment is typically dredged in the marine environment and pumped into scows, and the scow is then towed to as close to the discharge as possible, moored, and the sediment pumped out and through the discharge line. One large pump can send the material a distance of up to 8,000 feet, which is sufficient to deliver sediment to any site within the Parsons Complex. For scale, the distance from the UPRR Bridge to the base of the Five Fingers is 4,000 feet, so the pump could still effectively send the sediment twice that distance.

Pumping sediment into a receiver site is most effective if the sediment is behind containment dikes to keep the slurry contained so that the suspended sediment can settle out and deposit on the bed. Therefore, this option is best applied to any of the fingers (Five Fingers and the 6th finger) of the Complex, and to Rookery Lagoon. Silt curtains may be needed in the vicinity of the containment dikes if the slurry overtops the dike and flows into the central portion of the Parsons Complex. The curtains would control turbidity in their lee. Equipment needed for this operation are:

- A dredge at the sediment source site;
- A scow;
- A low-profile tugboat or other towing vessel;
- A large (1,500 horsepower) pump on the scow;
- Approximately 8,000 feet of discharge line; and
- Silt curtains (undefined number, based on scale of operation).

3.2.3 Environmental Effects of Sediment Placement

Environmental effects of potential sediment placement options are presented below.

3.2.3.1 Environmental Effects Common to All Sites and All Methods

Environmental effects of all actions are described below for short-term construction conditions and over the long-term after construction.

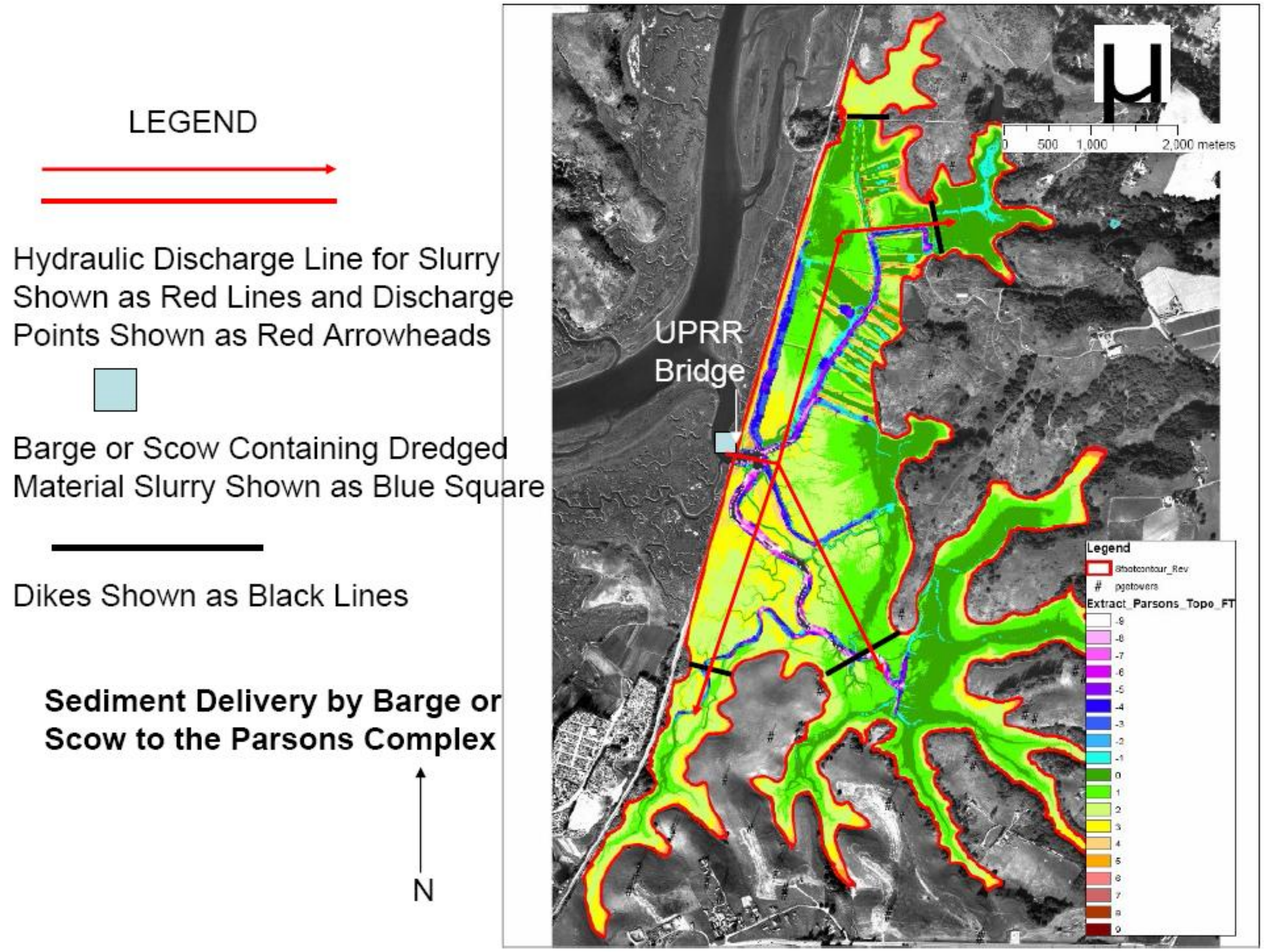

Figure 16 - Sediment Delivery by Barge or Scow to the Parsons Complex

Construction

During sediment placement activities, there will be a number of temporary environmental effects. These include temporary impacts on air quality, noise, aesthetics, recreation and biology. Each impact area is summarized below.

- Air Quality - Construction equipment and associated vehicles (trucks, worker cars) emit air pollutants. Total emissions are related to the number of each piece of equipment that is used, the number of hours per day of construction and the total duration of construction activities. Mitigations to reduce air pollutants include applying Best Available Control Technologies.
- Aesthetics - The presence of construction equipment and stockpiled sediments may temporarily degrade the natural character of the area.
- Biology – Various issues arise regarding biology including:
  - The placement of sediments will bury benthic organisms. If the placement rate is slow some organisms may be able to survive by burrowing upward through the new sediment. Most likely sediment placement will be rapid and most buried organisms will die. In addition, the change in elevation will change the type of organisms living in the sediment placement area (see Long-Term below). Benthic organisms would re-establish starting immediately and take one to two years to reach a relatively diverse mature community.
  - Sediment placement will generate turbidity which may affect organisms in adjacent areas by reducing light levels, clogging breathing and feeding appendages, and interfering with visual foraging. Turbidity can be reduced by using silt curtains during sediment placement.
  - Mobile organisms such as crabs, fishes, marine mammals, and birds will be disturbed by construction activities and most likely will avoid the construction site.
- Water Quality - Sediment placement will create turbidity. Turbidity can be minimized through the use of silt curtains. In addition, the use of equipment near water areas raises the possibility of introducing pollutants to the water via leaks and spills. Stockpiling of sediments creates the possibility that sediments could be washed into the water during storms. Preparation of a Stormwater Pollution Prevention Plan and/or Oil Spill Response Plan (for water based equipment) and the use of Best Management Practices reduces the possibility for water quality contamination during construction.
- Noise - The noise of construction equipment will disturb humans and animals nearby. Noise can be reduced by the use of mufflers on equipment or, if necessary, erection of temporary sound walls.
- Recreation - Sediment placement activities may interfere temporarily with the public's use and enjoyment of the Reserve.

Long-Term

- Biology - The conversion of mudflat to marsh habitat by the placement of sediment would be beneficial because it would increase the diversity of the system, help to reduce continued degradation of habitat by erosion, and restore salt marsh functions to the

Parson's Complex ecosystem. However, mudflat habitat would be lost. Therefore, there would be a reduction in area for mudflat invertebrates, fishes including sharks and rays that use mudflats for foraging during high tides, shorebirds that forage on mudflats, and harbor seals that haul out on mudflats.

3.2.3.2 Effects of Material Delivered in the Dry

In addition to the effects common to either placement method, material delivered in the dry will most likely involve truck traffic unless the railroad is used to deliver the sediment. Trucks delivering loads of sediment may interfere with regular traffic in the area and large trucks may create a safety hazard by restricting visibility of cars behind them. In addition, cars may try to pass slow-moving trucks. The impacts of truck traffic could be reduced by restricting truck traffic to non-peak hours and limiting the number of trucks on the road at one time.

The creation of access roads and stockpile areas will disturb terrestrial habitats. Access roads and stockpile areas should be located to avoid sensitive biological resources. Disturbed areas should be revegetated with native species. If sediment is obtained by scraping the hillsides, further disturbance to terrestrial habitats will occur. Areas denuded of vegetation for access roads or stockpiling may be subjected to erosion and washing of sediments into the water. Disturbed areas should be revegetated to prevent erosion.

3.2.3.3 Effects of Material Delivered in the Wet

Delivery of sediment in the wet would avoid the impacts of truck traffic and the impacts of creating access roads and stockpile areas. Sediment delivery in the wet would create more disturbance to marine habitats than sediment delivery in the dry. The noise of the dredge and pumping from the scow would disturb fishes and possibly otters and harbor seals. Bodkin and Rathbun (1988) observed that sea otter numbers in Morro Bay declined when harbor maintenance dredging occurred. Although they could not establish a cause and effect relationship, they speculated that otters may have left the harbor in response to the substantial increase in human activity associated with the project. The otters eventually returned to Morro Bay. It is possible that because the scow would be stationed near the UPRR Bridge at the entrance to the Parson's Complex that otters, leopard sharks and other organisms that use the Complex might be discouraged from entering during sediment placement activities. Delivery in the wet would bury and disturb aquatic organisms at the placement site, and may introduce exotic species of benthic organisms to the Parsons Complex.

The presence of the dredge, scow and associated vessel traffic (tug and crew boat) would have the potential to interfere with vessel traffic in Elkhorn Slough. Impacts could be reduced by coordinating with other vessel users to inform them of the project and by avoiding the more highly used areas to the extent possible.

Delivery of sediment in the wet probably would have less impact on recreational visitors to the Reserve than sediment delivery in the dry, because the dredge and scow would be located outside the UPRR Bridge and probably would be less visible to people on the trails in the Reserve than land-based equipment and stockpiles (depending on the location of the equipment and stockpiles). On the other hand, the dredge might disturb kayakers.

There is a risk of introducing species to the lagoon with material dredged from elsewhere. This would be particularly true of material pumped directly from the harbor because the environment in Parsons would be similar enough to the harbor that harbor organisms probably could persist there. It would be less likely for material delivered by truck as that material may likely be dry, or have dried prior to placement.

3.2.3.4 Specific Environmental Constraints Associated with Sediment Placement Alternative Areas

Site-specific environmental issues regarding sediment addition are presented below.

Five Fingers

The Five Fingers area (particularly the first and second fingers to the northeast) is highly used by leopard sharks. It also is used by a diversity of shorebirds and supports some large indicator mudflat invertebrates including razor clams and ghost shrimp.

The 6th Finger

No particular biological constraints have been identified in the 6th Finger, but it has been studied less than the other alternative sediment placement sites in the Parson's Complex. Based on radio tracking of leopard sharks, the 6th finger is little used by leopard sharks. The 6th Finger is located relatively far from the Reserve Visitor Center and main trail system. Therefore, sediment placement activities likely would have less impact on aesthetics and recreational use than the Five Finger, South Marsh, and Rookery Lagoon sites.

Rookery Lagoon

Rookery Lagoon is located near a rookery for great blue herons, great egrets, and double-crested cormorants. Activities associated with sediment placement in Rookery Lagoon could disturb nesting birds if sediment placement occurred during the breeding season. Local U.S. Fish & Wildlife Service representatives suggest not filling at this site due to its importance for nesting birds. However, this site remains included in fill options to enable evaluation of all possible actions. Rookery Lagoon also provides foraging opportunities for the nesting birds very close to their nesting site. Although great blue herons and great egrets forage in salt marsh, intertidal mudflats provide better foraging habitat because of the opportunity to feed on fishes when the tide is in. Cormorants feed primarily on fishes. Therefore, the conversion of mudflat to salt marsh would reduce the amount of time that they could forage in Rookery Lagoon (i.e. when the area is covered with water). In addition, the mudflats are used for foraging by shorebirds.
Rookery Lagoon is heavily used by leopard sharks. Conversion of the lagoon to salt marsh would largely eliminate this habitat for them. Rookery Lagoon is also located close to the Reserve Visitor Center and near trails. Therefore, sediment placement would have a temporary adverse impact on aesthetics and recreation.

Larger South Marsh Area

This area is highly used by waterbirds. The presence of the habitat islands adjacent to mudflats and channels provides opportunities for foraging close to roosting areas. South Marsh also supports an oyster population and key indicator mudflat invertebrates (fat innkeeper worms and razor clams). The larger South Marsh area is heavily used by leopard sharks. Thornbacks also use the area. South Marsh is readily visible from Reserve Trails, and, therefore, construction activities would have an aesthetic and recreational impact.

Central/West Marsh South of the Main Channel

Based on radio tracking studies, the channels within this area are highly used by leopard sharks. Leopard sharks pass through these channels to access the Five Fingers. This area is somewhat more visible from trails than Sixth Finger but is less proximate to Reserve trails than South Marsh, Rookery Lagoon and the northern part of Five Fingers (first and second fingers).

3.2.4 Sediment Addition Options Appropriate for Alternatives

Sediment addition options are described as they could likely be implemented in concert with the overall restoration alternatives.

3.2.4.1 Alternative 1: Water Control Structure At/Near The UPRR Bridge

All sediment addition options are feasible for implementation with Alternative 1. A water control structure at the UPRR Bridge will effectively function as a sediment containment structure by fixing the elevation of the wetland bed at the lowest point of the outflow pipes. Understanding that the lowest elevation of the outflow pipes will be perched significantly above the elevation of the existing channel bed, all areas upstream (east) of the structure will eventually rise in elevation to be no lower than the outflow pipe inverts, and probably higher with distance upstream from the structure. The process of aggradation of the wetland bed under this scenario would occur with or without manual sediment additions, but it would take much longer to occur if left to "natural" sedimentation processes (as the volume of sediment needed to raise the wetland is very large at approximately 2.3 million cubic yards without muting and less with muting). Intentional sediment additions to the wetland will significantly accelerate the process of aggradation of the wetland bed and formation of vegetated salt marsh.

With a sediment containment structure in place at the mouth to Parsons Complex under this alternative, any sediment addition option is productive and effective. Sediment placement at all locations presented in Section 3.2 of this report can be implemented. The two options of placing sediment at the west/central portion of the marsh and at the larger South Marsh area would be effective in this instance because installing smaller containment dikes is difficult at these locations and the larger tide control structure would serve as the ultimate containment device, rendering the smaller dikes unnecessary. The other options of adding sediment to the Five Fingers, the 6th Finger, and Rookery Lagoon are also all effective under this alternative. Internal diking at these sites would be less critical because of the sediment retention benefit of the tide control structure, but would still be recommended to induce more rapid establishment of vegetated salt marsh at the placement sites.

The priority of sediment placement options specified in this section should still be followed as it considers all factors for receiver site ranking (construction access and available working areas, proximity to sources, tidal prism reduction even with the existence of a tide control structure, rate of marsh creation per volume of sediment added, etc.). However, this alternative does provide flexibility to the State and ESNERR in implementing sediment additions. If options become available on short notice that preclude placement in the fingers or Rookery (e.g., an unanticipated offer for delivery by rail, which makes placement along the UPRR rail line most feasible), the site stewards could accept the fill with confidence that the material will likely remain within the Parsons Complex and not be lost to Elkhorn Slough, even if it does not remain at the placement site for the long-term.

One final point is that by muting the tides throughout the entire Parsons Complex, tidal flow velocities will be reduced over the entire hydraulic system. Therefore, erosion of bed sediment will be reduced and all sediment will tend more toward remaining in place than being transported elsewhere, leading to greater stability of the bed of the wetland over time. At some point in the future under alternative 1, containment dikes can be breached with the earthmoving equipment to allow tides to fully exchange between the fingers and the main body of the Parsons Complex. It is even possible that internal diking for these actions will eventually be unnecessary under alternative 1 because large-scale wetland bed stability will occur.

3.2.4.2 Alternative 2: Construct A Sill In The Main Parsons Slough Channel Near The UPRR Bridge

Wetland restoration alternative 2 for the Parsons Complex presents advantages to sediment addition that are similar to those for alternative 1. All sediment addition options are also feasible for implementation for alternative 2 in that the sill will serve as a sediment containment structure by fixing the elevation of the wetland bed at the elevation of the crest of the sill. The sill will be elevated above the bed of the existing channel and all areas upstream of the structure will eventually rise in elevation to equal that elevation, and rise higher with distance upstream from the structure. As with alternative 1, the process of wetland bed aggradation under this scenario would occur with or without manual sediment additions, but it will take much longer to occur if left to more natural sedimentation processes. Targeted sediment additions to the wetland will accelerate the process of bed aggradation and formation of vegetated salt marsh.

All sediment addition options presented herein are more effective with a sediment containment structure (sill) in place near the mouth to Parsons Complex. Sediment placement can be implemented at all locations presented in this report. The options of placing sediment at the west/central portion of the marsh and at the larger South Marsh area would be more effective in this instance because the sill will serve as the containment device. The other options of adding sediment to the Five Fingers, the 6th Finger, and Rookery Lagoon are also all effective under this alternative. Internal diking at these sites would still be recommended to induce more rapid establishment of vegetated salt marsh at the placement sites.

The priority of sediment placement options should be followed under this alternative. However, as with alternative 1, alternative 2 provides flexibility to the State and ESNERR in implementing sediment additions. If options become available on short notice that preclude placement in the fingers or Rookery for some reason (e.g., an unanticipated offer for delivery by rail), the site could receive the fill with confidence that the material will most likely remain within the Parsons Complex and not be lost to Elkhorn Slough, even if it does not visibly remain at the placement site.

At some point in time under alternative 2, internal containment dikes in the fingers can be breached with the earthmoving equipment to allow tides to fully exchange between the fingers and the main body of the Parsons Complex. Internal diking for these actions may eventually become unnecessary under alternative 2 because large-scale wetland bed stability should occur.

3.2.4.3 Alternative 3: Measures That Avoid Construction At/Near The UPRR Bridge

Alternative 3 differs from the previous alternatives in that no grade control of the wetland bed is proposed at the entrance channel. This causes the Parsons Complex elevation to continue to be influenced by head cutting occurring in the main channel and potentially lowering the channel and other areas in Parsons. This restoration scenario calls for grade controls (containment dikes) to be strategically placed at the downstream ends of the fingers or the base of the Five Fingers. As such, sediment containment will only effectively occur behind the containment dikes and therefore sediment addition should also only occur at those locations. Therefore, sediment options for the Five Fingers, the 6th finger, Rookery Lagoon, and possibly the larger South Marsh area (if done between existing ridges using and extending them as containment dikes) are appropriate for alternative 3, but not sediment at the west/central area of the Parsons Complex.

The lack of a downstream grade control for the entire Parsons Complex under this alternative limits the amount of fill that can accumulate within the wetland in the future and correspondingly limits the extent of restoration that can feasibly occur. Any sediment addition to this site that is not behind a containment feature will likely not remain the marsh for the long-term. Restoration can effectively occur as a benefit within the areas mentioned in the preceding paragraph, but not throughout the entire marsh. Another benefit of this alternative is that areas to be restored contain the largest portion of the existing tidal prism of the Parsons Complex and will therefore benefit the Elkhorn Slough as a whole. The advantage of this approach, however, is that all work done will remain within property owned and operated by the ESNERR and actions can remain somewhat independent of the UPRR (unless sediment delivery by rail is performed that requires the permission of UPRR to use their line).

3.2.5 Regulatory Issues Associated With Sediment Addition

Adding sediment to the Parsons Complex triggers the jurisdictional authority of permit agencies from all levels of government. Permits will be required from federal, state, regional, and local agencies to perform this action. The list of required approvals is:

- Sections 10 and 404 permit from the U.S. Army Corps of Engineers;
- Section 401 Water Quality Certification, Waste Discharge Requirements, and General Construction Activity Stormwater Permit from the Regional Water Quality Control Board;
- A Coastal Development Permit from the County of Monterey and possibly from the California Coastal Commission as well;
- Streambed Alteration Agreement from the California Department of Fish and Game;
- A Lease of State Lands from the California State Lands Commission; and possibly an
- Encroachment Permit from the County of Monterey Flood Control Agency (or equivalent).

In addition to the permits listed above, the U.S. Army Corps of Engineers will need to consult with NOAA Fisheries regarding impacts to Essential Fish Habitat, and they also may need to consult with U.S. Fish and Wildlife Service (USFWS) regarding impacts to sea otters if the USFWS thought there was enough potential for impact that a formal consultation is necessary.

Permitting a Multi-Year Sediment Additions Project

This type of project is similar to sediment addition programs along the state's coast referred to as opportunistic beach fill programs. This Parsons program would likely require approvals for a defined future period of time, likely 5 to 10 years, for the site to receive sediment from undefined sources that meet certain criteria for grain size, chemistry, and potential other properties. The permit is a general type of umbrella permit that allows a host of actions beneath the permit umbrella in compliance with pre-approved actions. Conditions will include extensive monitoring for project impacts and for habitat recruitment to gage the success of the approach. Permits can be reissued, extended, or amended prior to their expiration at 5 to 10 years and may be reissued if findings indicate the program was successful and/or could be improved and continued.

This program has never been attempted with the County of Monterey. Areas that possess active permits as of this writing include those listed below:

Santa Barbara/Ventura Counties – referred to as the South Central Coast Beach Enhancement Program (SCCBEP), see url http://www.beacon.ca.gov/projects/001-SCCBEP.htm for more specific information.
Agency: Beach Erosion Authority for Clean Oceans and Nourishment (BEACON)
Contact: Gerald Comati, Project Manager
Phone: (805) 962-0488
E-mail: gerald@com3consulting.com
Additional Contact: Brian Brennan, Executive Director and Ventura Councilman
Phone: (805) 654-7827
E-mail: bbrennan@ci.ventura.ca.us

The City of San Clemente
Contact: Bill Humphreys, Lifeguard Chief
Phone: (949) 361-8260
E-mail: humphreysb@san-clemente.org

The City of Carlsbad:
Contact: Steve Jantz, Associate Engineer
Phone: (760) 602-2738
E-mail: sjant@ci.carlsbad.ca.us

Other agencies presently in process for the same type of permits are the Cities of Oceanside, Encinitas, Solana Beach, Coronado, and Imperial Beach.

The steps required to secure permits include:

1. Define the project description specifying the quantity of sediment additions, quality of sediment to be added, locations of placement, and timing of placement;
2. Conduct a pre-application meeting with all agencies together to present the concept and define all regulatory requirements;

3. Complete environmental review and a wetland delineation;
4. Submit completed permit applications to the agencies with any filing fees;
5. Perform follow-up with the agencies to answer questions and resolve outstanding technical issues;
6. Negotiate with the agencies on draft permit conditions; and
7. Perform pre-restoration monitoring to quantify the baseline condition.

Permits will possibly require the proponent to request a permit extension or amendment prior to the expiration date to extend the permit period. This request will need to be supported with results of monitoring of project effects.

Issues Encountered to Secure Permits

Securing the permits required resolution of issues pertaining to trucking, turbidity, and biology.

Trucking was a concern for traffic, safety, and general nuisance (noise and congestion). Trucking issues were resolved by limiting the number of trucks per hour and per day, thus limiting the quantity of fill that can be placed over time.

Turbidity was a concern for beach users and foraging birds from local lagoons. Turbidity was addressed by the agencies requiring monitoring during construction to quantify levels, and to reduce sediment placement rates during construction if turbidity levels became excessive relative to Water Board standards.

Biology was a concern for impacts to habitat. The project description was defined to limit the placement area to avoid sensitive habitat, the grain size to mostly sand rather than silt (to reduce suspended sediment concentrations and indirect burial of habitat), and the timing placement to avoid nesting seasons for sensitive species.

Habitat Impacts As Self-Mitigating

This project is anticipated to be self-mitigating and not require mitigation. The project objective is to significantly improve degraded marsh conditions and as such, would be viewed as a benefit by the resource agencies. Long-term net benefits from this project can be shown to outweigh temporary adverse impacts from construction. If proposed actions were designed and implemented to be as sensitive as possible to existing high value habitat, the net effect on habitat would be shown to be positive. Conditions of permit approvals will include monitoring and potential adaptations over time, but the agencies will likely not require mitigation for actions other than blatant and willful destruction of habitat.

3.2.6 Critical Issues for Further Study

Issues requiring further study include to advance this project forward include:

- The need to amend new soils for fertility to support vegetated salt marsh habitat;
- Potential available sediment sources;

- Biological assessment (and possibly additional surveys) of upland areas that would be impacted by trucking and sediment delivery and placement activities; and

- Designation of vehicle access routes to the Complex from the street.

These issues can be addressed during the preliminary engineering phase of the project.

4.0 RECOMMENDATIONS

Based on the findings in this report the following recommendations are made for the State and ESNERR to consider as part of this wetland planning effort:

1. Determine prioritization of sediment addition locations;

2. Based on the prioritization, rank the types of delivery options (truck, rail, afloat) in order of preference and indicate if any are unacceptable;

3. Consider the approach of future implementation of a pilot project to test an approach;

4. Carry the preferred delivery option(s) and any pilot project forward as part of concept design of wetland restoration alternatives 1 through 3, and analyze them as part of the next task for wetland planning (Develop and Evaluate Restoration Alternatives) including generating more detailed cost information for decision-making;

5. Determine from the analyses the sediment delivery option(s) that remain acceptable and any pilot project efforts and include them in the final Wetland Restoration Plan.

Subsequent actions after the Wetland Restoration Plan is accepted will entail the tasks of environmental review, permitting, project design for construction, and actual construction with monitoring. These tasks will be elaborated upon at a later stage of this planning effort.

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CHAPTER 4

PARSONS SLOUGH RESTORATION PLAN

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

PARSONS SLOUGH RESTORATION PLAN

4.1. Chapter Summary

The Parsons Slough Sill project presents the opportunity to advance two goals of the Parsons Slough Restoration planning process: preserving tidal marsh and soft subtidal habitats in Elkhorn Slough by reducing tidal scour while preserving high quality fish habitat in Parsons Slough. The Parsons Slough Sill will not, however, restore salt marsh in Parsons Slough. That would require a second project, which could only be implemented following resolution of specific planning and engineering issues. The Parsons Slough Sill would be compatible with such a project, but would not be dependent on it. That separate salt marsh restoration project would be compatible with the Parsons Slough Sill, but would not be dependent on it, either.

The strengths and weaknesses of the alternatives presented in Chapter 3 were considered in detail, with two major outcomes:

- Restoring fully tidal salt marsh in the Parsons Complex is likely to be costly and to require substantial additional planning steps and technical investigations.

- A simpler project that prioritizes the preservation of existing high quality habitat in both Elkhorn Slough and the Parsons Complex could be implemented at a small fraction of the cost of a project that restored extensive tidal marsh.

Following consideration of the alternatives, the Parsons Slough Restoration Team (PRT) recommended eliminating many of them. The PRT eliminated Alternative 1 and all of the subalternatives of Alternative 3 that involved lowering the tidal frame. These were considered likely to result in undesirable water quality conditions in the Parsons Slough Complex, a lack of connectivity between the resulting marsh and the rest of the estuary, a lack of resilience to sea level rise, and high operations and maintenance costs. In essence, the PRT determined that the Elkhorn Slough estuary has hundreds of acres of salt marsh with severely restricted tidal exchange, that these sites exhibit diminished ecologic function, and that the best use of the Parsons Complex was not to increase that acreage.

Alternative 2 was the only alternative that would advance all three project goals, restoring fully tidal salt marsh to the Parsons Slough Complex. Verifying the feasibility of Alternative 2 will require additional technical investigations to evaluate the suitability of sediment for addition. With a projected cost of approximately $50 million and in the context of the current economic crisis, this alternative was not viewed as the highest priority.

Following this review process, ESNERR staff recommended a project to advance Goals 2 and 3: preserve declining habitats in Elkhorn Slough while conserving high quality subtidal and intertidal habitat in the Parsons Slough Complex. That project, the Parsons Slough Sill, would consist of an adjustable water control structure that would be operated concurrent with a monitoring program to ensure adverse impacts are avoided. This project was endorsed by a joint meeting of the Strategic Planning Team and Science Panel of the Tidal Wetland Project in June 2009. The estimated cost to design, permit and build this project is $ 4 million, a fraction of the cost of the other alternatives.

The Parsons Slough Sill would involve placement of a water control structure as a submerged tidal barrier across the mouth of Parsons Slough. The structure would result in some muting of the tides, but much less than Alternative 1. The reduction in tidal prism would reduce current velocities and tidal scour in the main channel of Elkhorn Slough, advancing Goal 2. The structure would be adjustable over a range of configurations to enable optimization among multiple management objectives, such as maintaining sufficient tidal exchange to preserve water quality in Parsons Slough. An open channel geometry with an invert elevation of -5 feet North American Vertical Datum (NAVD) would provide passage for fish and wildlife, advancing Goal 3.

The Parsons Slough Sill would be compatible with, but not dependent on, a later project that would conduct large scale sediment addition to restore tidal marsh and advance Goal 1. Similarly, projects involving sediment additions to restore tidal marsh would be compatible with, but not dependent on, the Parsons Slough Sill. Both projects described here – the sill and the sediment additions – would also be compatible with projects evaluated previously by the Tidal Wetland Project that would alter the mouth of Elkhorn Slough at the Highway 1 Bridge or with a New Ocean Inlet.

Based on modeling by Moffatt and Nichol (2009), the sill in its most open setting would preserve the existing tidal range, tidal prism and residence time of water in Parsons Slough. In its most restricted setting, the tidal range would be reduced by approximately 50%, the tidal prism of Parsons Slough would be reduced by approximately 30% and peak current velocity in the main channel of Elkhorn Slough would be reduced approximately 20%. That reduction in ebb current velocity is expected to reduce tidal scour in Elkhorn Slough and help shift the hydrodynamics and geomorphology of the estuary towards conditions more likely to sustain salt marsh and soft subtidal habitats in the future.

The long term effort to restore salt marsh in Elkhorn Slough remains a priority of the Tidal Wetland Project and the PRT. Sediment addition will remain under consideration as a potential restoration option. Further evaluation of the viability and environmental impacts of sediment addition will be required to determine whether this approach is advisable.

The next steps for tidal marsh restoration are:

- Advance the implementation of the Parsons Slough Sill by funding and managing the design, environmental compliance and construction phases.
- Evaluate available sediment through experiments and/or trial restoration projects.
- Identify the highest quality mudflat and subtidal habitat, which sediment addition projects should avoid. The process should engage scientists, naturalists and other stakeholders knowledgeable of the Parsons Slough Complex and its existing use of the site by sharks and rays, sea otters, harbor seals, and shorebirds.
- Identify and explore strategies for reducing the costs of sediment delivery and placement.
- Evaluate the costs and benefits of tidal marsh restoration in the Parsons Slough Complex compared to other sites in Elkhorn Slough, such as the ESNERR properties Minhoto and Pick-N-Pull.
- In light of the findings related to cost, feasibility and habitat quality, select the locations of sediment additions, and refine the target proportions of salt marsh, mudflat and subtidal habitats.
- Based on the outcomes of this process, determine whether and how to proceed with subsequent implementation steps.

4.2. Alternative Evaluation Process

The Parsons Restoration Team (PRT) for the Tidal Wetland Project (composed of members of the Science Panel and Strategic Planning Team, or SPT, for Elkhorn Slough) determined alternatives worth considering for restoration at the Parsons Complex. Three main restoration alternatives were considered. Alternatives included:

- Alternative 1 – Water Control Structure at the Union Pacific Railroad Bridge
- Alternative 2 – Sill Downstream of the Railroad Bridge and Sediment Additions
- Alternative 3 – Internal Diking and Sediment Additions (with five subalternatives and five muting scenarios, for 21 possible combinations total for Alternative 3)

The strengths and weaknesses of these alternatives were considered in detail, with two major outcomes: All the three goals of the Parsons Slough Project could be accomplished simultaneously only with a project of substantial cost and following favorable outcomes from additional technical investigations. Goals 2 and 3, however, could be accomplished on a faster timeline with a simpler project that could be compatible with but not dependent on a larger project implemented later.

ESNERR staff and the PRT reviewed the Draft Alternatives Analysis Report (Moffatt & Nichol 2007) and dropped Alternative 1 and all of the subalternatives of Alternative 3 that involved muting and lowering the tidal frame to restore salt marsh in the Parsons Complex. The group identified that Alternative 1 was likely to present undesirable water quality conditions, less-than-optimal habitat outcomes because of a lack of connectivity between the resulting marsh and the rest of the estuary, a lack of resilience to sea level rise, and on-going costs managing the water control structure. The Alternative 3 muting subalternatives were also considered likely to have similar flaws. In essence, the PRT determined that the Elkhorn Slough estuary has hundreds of acres of salt marsh with severely restricted tidal exchange, that these sites appear to exhibit diminished ecologic function, and that the best use of the Parsons Complex was not to increase that acreage.

However, restoring fully tidal salt marsh in Parsons Slough is quite challenging. It was determined during the planning process that accomplishing Goal 1, (restore and enhance intertidal marsh habitats… within the Parsons Slough tidal wetland complex) was not feasible on a planning horizon of less than three to five years because of feasibility issues associated with sediment addition. The longer term feasibility of that goal hinges on whether technical issues related to sediment additions can be resolved. These tradeoffs are explored in detail in Chapter 3.

While those issues should be pursued, the group recommended that action be taken in the near term to advance Goals 2 and 3: preservation of declining habitats in Elkhorn Slough while conserving high quality subtidal and intertidal habitat in Parsons Slough. That project, the Parsons Slough Sill, would consist of a water control structure that functions in ways similar to the water control structures of both Alternatives 1 and 2 as presented in the alternatives analysis. This project would advance those goals in a technically and economically feasible manner with a short to medium implementation timeline.

Goal 1 was set aside because of challenges to the restoration of salt marsh at Parsons Slough, including:

1. Restoration of salt marsh with a full tidal range requires large sediment additions, which is not readily feasible for reasons including:
    a. Sufficient quantities of fine sediment are only available from the near shore environment in Monterey Bay or from the Graniterock quarry, with lesser quantities from Moss Landing Harbor;
    b. These sediment sources are expensive; and
    c. The environmental impacts of these sediment additions are unknown, and the timeline for evaluating those impacts may require additional years of planning and technical analysis.
2. Strongly muting the tidal range, the primary alternative to sediment addition, was not recommended by the Parsons Slough Team because strongly muting the tides in other parts of Elkhorn Slough has been observed to
    a. compromise wetland functions, such as the exchange of energy and organisms with the estuary,

b. result in water quality problems, and

c. increase maintenance costs.

3. Muted tidal marshes are less resilient to sea level rise in settings such as Parsons Slough where the local sediment supply is low.

Despite these challenges, the long term effort to restore salt marsh in Elkhorn Slough remains an important priority set by the SPT and PRT. Subalternatives of Alternative 2 and Alternative 3 without tidal muting were retained for further consideration as potential restoration options. Both of these alternatives are heavily dependent on the large scale addition of sediment to the Parsons Complex. Further evaluation of the viability and environmental impacts of sediment addition will be required to determine whether these alternatives are advisable. The impact and cost of sediment addition may be less in other parts of the Elkhorn Slough estuary, and the next step of assessment should also consider other sites where the cost per unit area of restored salt marsh is likely to be lower, such as at the Minhoto and Pick-N-Pull properties of the Elkhorn Slough National Estuarine Research Reserve.

Following the presentation of the recommended course of action, below, this chapter provides more information about these restoration alternatives to guide future investigations and decision-making.

4.3. Recommended for Implementation: the Parsons Slough Sill

The Parsons Slough Sill would involve placement of a submerged tidal barrier (termed a 'sill') as a water control structure across the mouth of Parsons Slough. The structure would result in some muting of the tides, but not as much as was required under Alternative 1 to restore broad tidal marshes. The resulting reduction in tidal prism would reduce current velocities and tidal scour in the main channel of Elkhorn Slough, advancing Goal 2 of the project. The submerged weir section of the structure would be adjustable over a range of conditions to enable optimization among multiple management objectives, such as maintaining sufficient tidal exchange and flushing to provide acceptable water quality in Parsons Slough. An open channel configuration was selected over an array of culverts to provide better passage for fish and wildlife and to allow for greater flexibility with respect to sea level rise, meeting Goal 3. This project would provide substantial environmental enhancement in isolation, but it would also be compatible with sediment additions to advance Goal 1, if those are determined to be desirable in the future. The project would be similarly compatible with, but not dependent on large scale actions at the mouth of Elkhorn Slough. The estimated cost of this project is $ 4 million, a fraction of the cost of the other alternatives.

Several new ecologic and management objectives were developed for this alternative:

4.3.1. Ecologic objectives of the Parsons Slough Sill

- Promote the recovery of soft subtidal sediments by reducing peak current velocities and tidal scour, particularly in Parsons Slough and in Lower Elkhorn Slough, from Parsons Slough to Moss Landing Harbor
- Promote the recovery of salt marsh in Elkhorn Slough by reducing tidal scour, as that will (1) increase the retention of sediment in the estuary, making sediment more available to build tidal marshes, and (2) reduce the duration of inundation of salt marshes at the head of the slough by reducing the run up of the tides
- Improve or sustain ecosystem health with respect to dissolved oxygen and other indicators of eutrophication in Parsons Slough
- Accommodate the movement of fish and wildlife in and out of Parsons Slough, specifically sea otters, harbor seals, flatfish, sharks and rays

4.3.2. Management objectives of the Parsons Slough Sill

- Adjustment of the structure should be feasible with existing staff resources.
- The structure should be designed to function with minimal maintenance for at least 30 years, with a project lifespan of at least 50 years.
- The structure should be able to be dismantled if its effects are determined to be undesirable.
- Structural failure must not endanger life or property.
- The structure should enable the tidal range in Parsons Slough to be managed from unrestricted to approximately 60 percent of the unrestricted tidal range

4.3.3. Design Concept

The Parsons Slough Sill structure would block about 75% of the existing channel cross sectional area. A central portion of the structure would be permanently open. This notch would be 8 meters (25 feet) wide, with a crest elevation of -1.5 meters (-5 feet) NAVD 88. The remainder of the structure would consist of an adjustable crest. The width and elevation of the crest would be adjusted using panels, gates or stop logs, which could be added or removed using an integral hoist, portable motors or a boat-mounted hoist.

Preliminary modeling (Moffatt and Nichol 2009) indicated that in its most open configuration, the sill would allow sufficient tidal exchange to preserve the existing tidal range, tidal prism and residence time of water in Parsons Slough. This analysis indicated that in its most restricted configuration, the tidal range would be reduced by approximately 50%, the tidal prism of Parsons Slough would be reduced by approximately 30% and peak current velocity in the main channel of Elkhorn Slough would be reduced approximately 20%. That reduction in ebb current velocity is expected to reduce tidal scour in Elkhorn Slough and help shift the hydrodynamics and geomorphology of the estuary towards conditions more likely to sustain salt marsh and soft subtidal habitats in the future.

This concept is based on Alternative 2, which consists of a sill (a subtidal ridge) in the main entrance channel to the Parsons Complex, but without the large-scale sediment additions to raise the site to the elevation suitable for vegetated salt marsh. Figure 4-1 shows Alternative 2, including the location of the sill and areas of potential future sediment addition.

The base of the structure would consist of rock or sheet piling. The adjustable submerged weir elements of the structure would consist of flashboards or hinged tide gates. Materials would be placed by barge and/or rail based equipment. A rock based structure would be composed of large armoring stones overlying smaller material, and would be imbedded/founded deeply enough below the channel bed to remain stable and prevent undermining of the structure from channel erosion into the 50-year future. Smaller rock would be placed as scour protection on the crest of the sill, along the channel banks adjacent to the sill, and on the channel bed just upstream and downstream of the structure. A sheet pile structure would also likely include rock armor as scour protection.

Figure 4-2 shows a plan view of the sill, and Figure 4-3 shows a conceptual profile, while Figure 4-4 shows a cross section. Figure 4-3 shows the possibility that the bed elevation of the Complex will rise over time through the deposition of ambient sediment. The rate of sediment deposition is likely to be slow because of the low suspended sediment concentrations in the water column. The intentional addition of sediment is not contemplated as part of this project, but may be considered in the future as part of efforts to restore large extents of salt marsh in the Parsons Slough Complex (discussed later in this chapter).

The sill could be raised over time to keep pace with sea level rise, which assumes that the rail line is also raised over time.

This adjustable sill concept grew out of the analysis of Alternative 2 (described in Chapter 3). The structure analyzed for that alternative was intended to arrest channel head-cutting and reduce sediment export from the Parsons Complex. Modeling results indicated it would also slightly retard tidal flows and thus reduce flow velocities at areas away from the sill. Following up on this observation, a modified sill was modeled with a narrower opening to further reduce flow velocities in other areas. When the cross section was reduced by 50% by adding rock along the channel banks to further constrict the cross-section, the tidal flow velocities were further reduced at areas away from the sill. The recommended structure allows this restriction to be conducted with flashboards rather than rocks, so that it can be reversed later if necessary.

4.3.4. Managing Risk and Accommodating Uncertainty

The concept of the Parsons Slough Sill is an adjustable subtidal barrier designed and managed to minimize impacts to existing habitats and ecosystem values. Nonetheless, restricting tidal exchange is an unconventional restoration strategy. Traditional tidal restriction projects have relied on culverts and flap gates, which are commonly associated with negative effects to aquatic species related to reduced circulation, poor water quality, and barriers to animal movement. This project proposes a different approach, using an open channel to maximize connectivity, but it is a novel design with few examples to use as a guide.

Despite a level of risk and uncertainty, we have chosen to pursue a sill because restricted conditions match the historic reference condition, and it is a sustainable approach to reversing the trends of habitat loss in the estuary as a whole.

The adjustable nature of the structure is crucial. A process of joint fact finding would guide the adjustment of the structure to reduce tidal exchange while managing the risk of eutrophication and the risk of interfering with the movement of fish and wildlife. Monitoring would be conducted to observe the effects on the ecosystem of the structure before and after installation and with each adjustment.

The optimization and adaptive management process would use the adjustable nature of the structure to characterize and manage risk. The concept is that width and depth of the sill opening would be adjusted through an optimization process based on monitoring the achievement of project goals. This would ensure that the tidal prism of Elkhorn Slough is reduced but that overall ecologic health, as defined in the joint fact finding process, is not compromised.

The structure would be adjusted through different configurations, with monitoring to compare the results against management targets and thresholds. That process would last for perhaps five years following construction. The best configuration would then be selected based on criteria determined prior to construction, and refined during the adaptive management process.

Annual or seasonal adjustment is presently viewed as undesirable for cost reasons. The most feasible management scheme would settle on a fixed position after a period of adjustment, and then the structure would be left unchanged for several years at a time. Long term changes to conditions or changed management objectives would be the main reason for adjustments after that period. The preferred design would not require frequent operation or maintenance to provide lasting ecologic benefits.

Figure 4-1– Sill Location

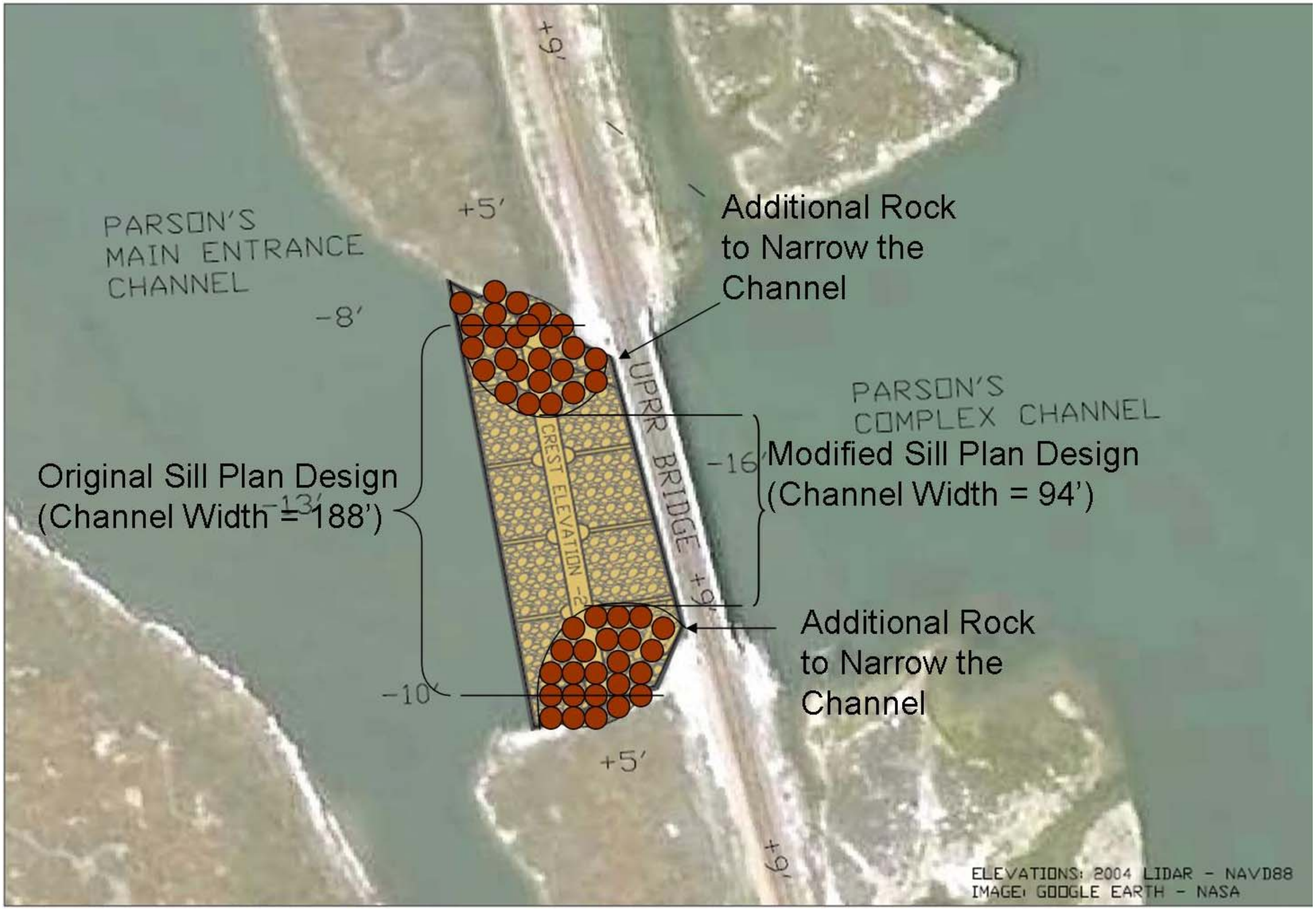

Figure 4-2 – Alternative 2 Sill Plan

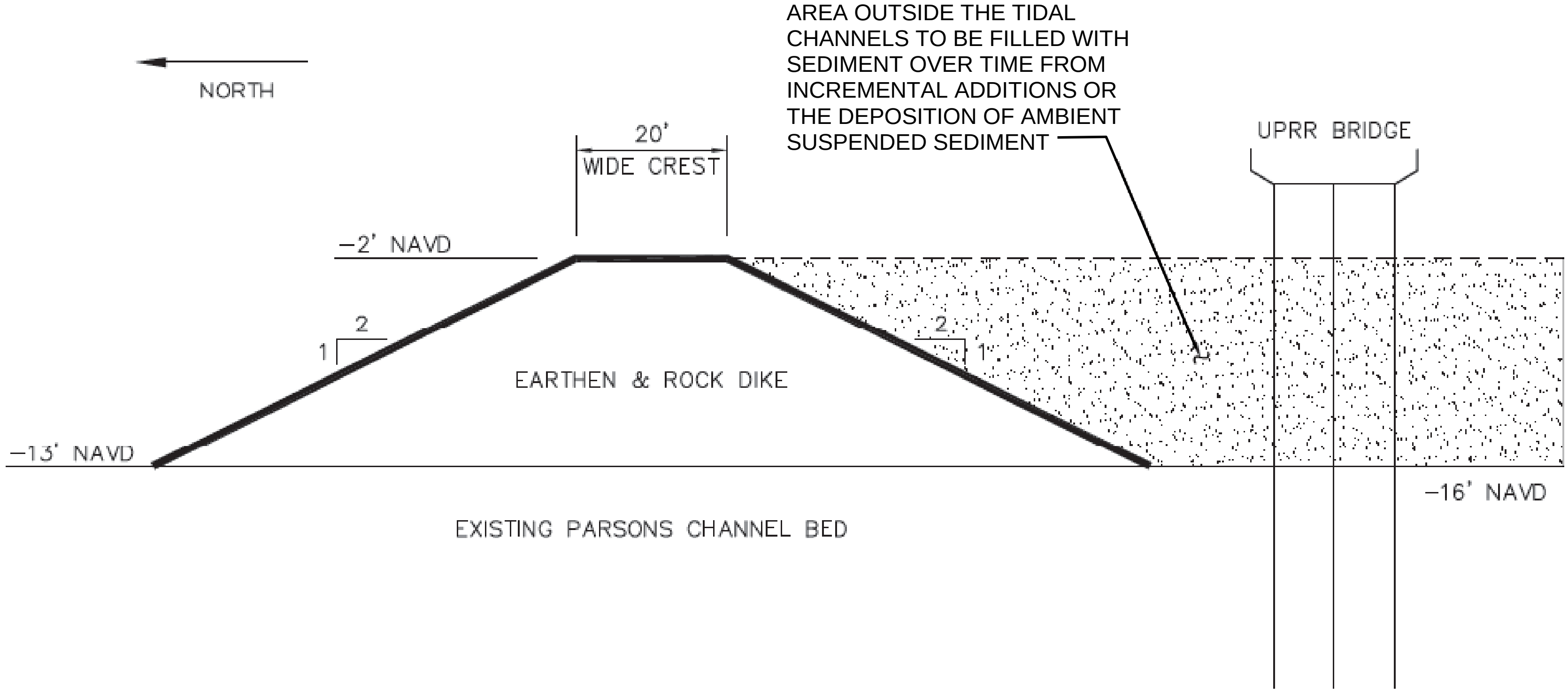

Figure 4-3 – Sill Profile

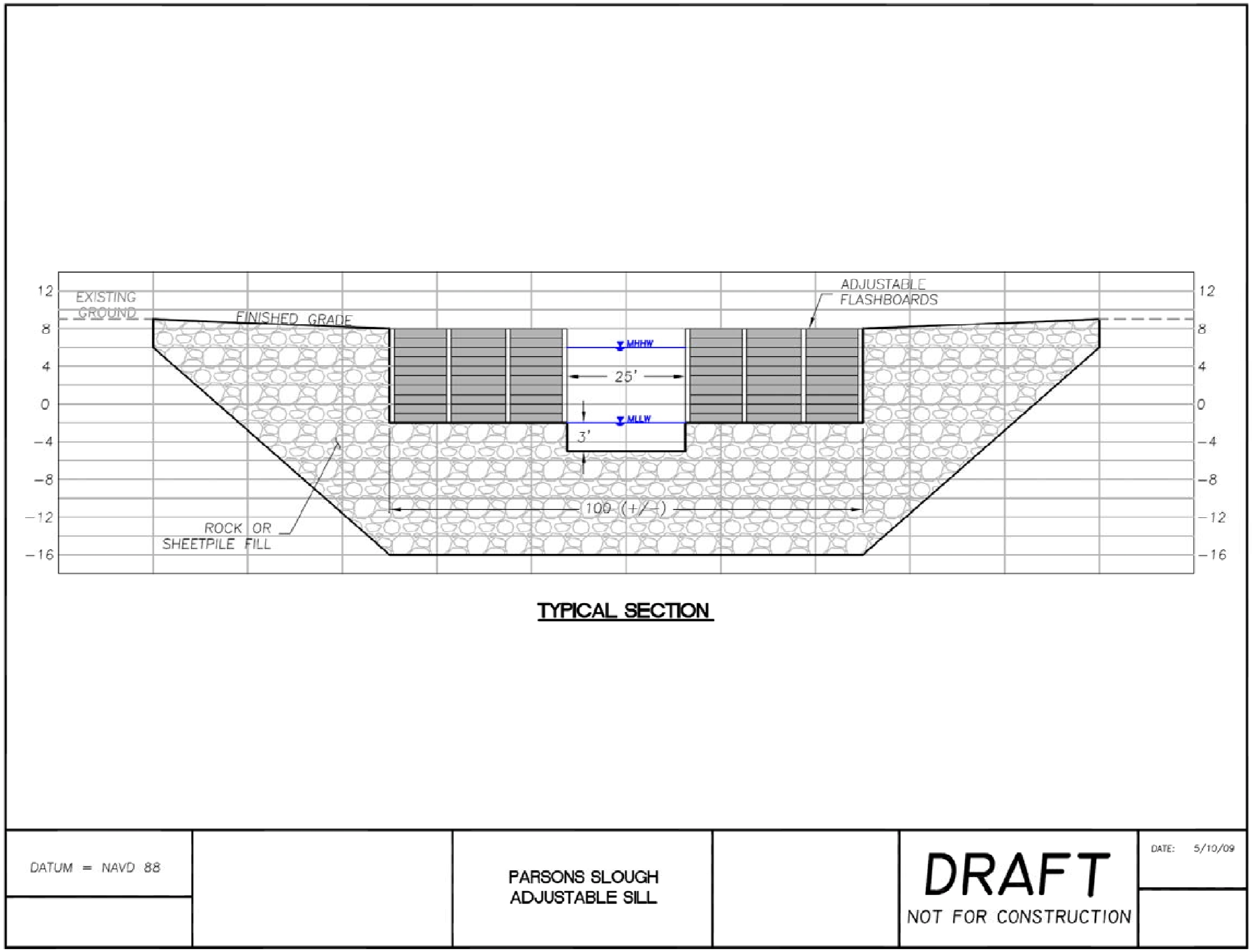

Figure 4-4 – Sill Cross Section

4.3.5. Implementation Plan for the Parsons Slough Sill

In June 2009, the Elkhorn Slough Foundation received funding from the National Oceanic and Atmospheric Administration for the design, regulatory compliance and construction of the structure. Funding was also awarded to initiate the adaptive management process. Work was initiated in July 2009, and at the time of this writing the engineering design and regulatory compliance phases are getting underway. After construction, the adaptive management process will enable optimization of the structure to new data and any changes to management objectives.

The Parsons Slough Sill will substantially advance Goals 2 and 3 of the Parsons Slough Restoration Project, but it will not advance Goal 1, the restoration of tidal marsh in Parsons Slough. To accomplish Goal 1 without substantial muting of the tides, will require sediment additions. Numerous unresolved issues affect the feasibility of sediment additions to restore tidal marsh in Parsons Slough. Future planning should evaluate those issues to determine whether such an approach to restoration is viable.

4.4. Future Planning for Tidal Marsh Restoration

This section describes in greater detail the restoration actions that would be taken to restore the Parsons Complex to tidal marsh. It is important to note the adjustable Parsons Slough Sill is a stand-alone project that would advance the goal of supporting salt marsh sustainability in Elkhorn Slough while protecting high quality habitat in the Parsons Slough Complex. However, it can also serve as the first step to salt marsh restoration in the Parsons Slough Complex, as recommended by the planning and feasibility assessments described below.

Salt marsh restoration in Parsons Slough can be accomplished with the guidance of this section of the Restoration Plan. This section presents actions and options for the ESNERR to follow toward project implementation. The vision for restoration of the Parsons Complex aims for a tidal wetland ecosystem with the largest component of salt marsh possible, given existing and future constraints (that are physical, economic, environmental, and social in nature). Restoration to that condition would include the installation of a sill, and infilling the Complex with suitable sediment to create more vegetated salt marsh habitat. The sediment addition element would proceed only if the ecologic benefits outweighed the environmental impacts and project costs.

This long-term vision for the site would not be accomplished in one single project. Restoration of the Parsons Complex could be accomplished through a series of actions, each of which could stand alone, but which are fully compatible and support one another synergistically.

These sediment additions would provide the following benefits:

- Immediate vegetated marsh benefits;
- Proof of concept for sediment addition for salt marsh restoration using available fill;

- Generate momentum by accomplishing visible accomplishments rapidly; and
- Provide component projects that can be funded individually.

If deemed appropriate from monitoring results, long-term actions could be taken to progress toward complete restoration of the complex with larger scale sediment additions. A more detailed discussion of each phase and its respective actions is presented below.

A restoration plan is presented that calls for independent restoration projects. The first is installing the Parsons Slough Sill. Possible later projects include tidal marsh restoration via sediment addition, if the associated technical issues are resolved, and the trade-offs are determined to be acceptable.

If sediment addition is selected, filling some of the fingers behind containment dikes could be done incrementally as funding and fill becomes available. This approach would allow gradual changes to occur at Parsons that could be monitored and analyzed. The recommended order of areas for restoration is discussed below in Section 4.4.3.3. As discussed below, the decision process for placing sediment will require consideration of many factors. Chief among these is the high quality existing habitat for certain wildlife, such as elasmobranch nursery areas, which should be low priority for sediment addition. As a result of these and other considerations, stakeholder agreement has not been reached on the ideal long term habitat distribution for Parsons Slough.

A series of next steps needs to be completed in anticipation of restoration, including the following:

- Discussion with stakeholders about whether to proceed with future independent projects;
- Determine the desired proportion of future habitats and high quality existing habitats to avoid;
- Further evaluate sediment quality and the feasibility of delivery
- Approach project partners for cooperation;
- Apply for project funding;
- Perform preliminary engineering of certain project elements;
- Perform a wetland delineation;
- Complete environmental review;
- Secure permits;
- Complete final engineering for construction;

- Perform pre-restoration monitoring;
- Complete construction;
- Perform post-restoration monitoring; and
- Continue to perform adaptive management over time based on monitoring results.

Restoration of the Parsons Complex requires a series of planning and engineering tasks to be performed in the near-term. The steps to be taken are those listed below and should be taken in the order listed.

4.4.1. Determine Desired Proportion of Future Habitats

Wetland restoration would modify habitats at the project site. The restoration plan can be tailored to restore certain habitat targets. Existing habitat at the Parsons Slough Complex consists of 4% vegetated salt marsh and nearly 90% subtidal and mudflat habitat combined. Restoration can target an increase in the percentage of vegetated salt marsh, but it should target an appropriate blend of other habitat types as well. Although the focus has been on restoring vegetated salt marsh at Parsons, intertidal mudflat, eelgrass, subtidal, transitional, and upland habitats all serve important functions. The ESNERR, with guidance from the Parsons Restoration Team, will ultimately define the desirable proportions of all site habitats. This report does not propose a particular habitat mix, but provides additional information for consideration as part of future decision-making. Considerations for assessing the appropriate habitat proportions for the site are presented below.

Benefits of planning for particular habitat proportions on-site include:

- Definition of the ultimate habitat distributions is key for project design;
- Optimizing habitat proportions in the plan may reduce impacts to existing functions; and
- A lower overall quantity of fill may be required if habitats at lower elevations can be created/preserved in the plan.

However, achieving an inappropriate habitat mix may not result in what is needed for the site and/or region, and may lead to lower overall habitat quality than is desired (and it may be irreversible). Determining the optimal distribution of habitats is difficult and specific guidelines on what habitat proportion is best for this site have not yet been provided from resource agencies.

4.4.1.1. Historic and Target Habitat Proportions

Identifying the appropriate habitats for a particular site typically involves considering the site's historic habitat condition compared to its pre-restoration condition, and assessing any needs within the region that this site could provide. Comparing historic and existing conditions is straightforward using data collected by the ESNERR. A short analysis of that is provided below.

Assessing regional habitat needs that the site could provide requires input from the resource agencies and stakeholders, and is best deferred until the groups can meet and initiate those discussions. Historic habitat areas are from maps of 1870, and existing conditions are represented by data from 2000. The 1870 data were provided by ESNERR staff.

Table 4-1 shows historic and existing habitat proportions at the Parsons Complex using Geographic Information Systems (GIS) data provided by the ESNERR (Van Dyke 2009). Freshwater areas existed on-site after 1870 with modifications by the Empire Gun Club. Dikes were erected and spring water was trapped to provide duck hunting ponds. In addition, some influence was exerted on the site from the Salinas River, and to a much lesser extent the Pajaro River. However, evidence that the area was historically mostly salt marsh (over the last 1,000 years) with less brackish and freshwater marsh prior to man's influence is presented in research of paleocores (Watson 2006). Watson's study indicates that from 1,000 to 200 years ago marsh extent at Elkhorn Slough ranged from 48 to 61% of the extent of marsh present between 1800 and 1950. This may have been due to increased watershed erosion during the period after 1800. That interpretation was based on a relatively few samples, and a follow-up study was initiated in 2009. Elkhorn Slough may have been somewhat less saline than present, and more variable with respect to estuarine salinity (Watson 2008). The proportion of freshwater habitat on-site diminished greatly with removal of the diking and irrigation system of the Gun Club, and possibly from the rerouting of the Salinas and Pajaro Rivers out of the Elkhorn Slough watershed. As a result, the Parsons Complex presently consists nearly entirely of saltwater habitat.

The historic salt water habitats in 1870 were dominated by vegetated salt marsh (approximately 92%), and with remaining areas as mudflat and subtidal channel areas (6% total). A consideration of historic 1870 conditions shows that the balance of vegetated to unvegetated marsh areas has been inverted since historic times, suggesting the emphasis should be placed on re-creating vegetated salt marsh. The exact proportion of vegetated marsh can be determined by the ESNERR with assistance from the Restoration Team.

4.4.1.2. Restoration of Mudflat and Salt Marsh

Because of the existing under-representation of vegetated salt marsh habitat, the ESNERR suggested that two scenarios be consideration to bracket a reasonable range of possible habitat proportions for restoration. Direction from the ESNERR is that the habitat proportion scenarios for consideration in restoration should include:

- Maximum vegetated salt marsh and minimal mudflat; and
- One-half vegetated salt marsh and one-half mudflat (a 50/50 split of habitat type).

Maximum vegetated salt marsh would represent the largest amount of salt marsh area that could physically be created on-site without losing the subtidal channels and some measure of valuable mudflat area. This scenario is similar to the restoration surface envisioned by Alternative 2, consisting of the sill with fill. Approximately 280 acres of vegetated salt marsh would be created by that option for a 60% cover, with mudflat occupying 25% of the site, and the remaining 15% consisting of subtidal channels (9%) and upland/transitional areas (6%). So the maximum vegetated salt marsh and minimal mudflat scenario assessed here consists of 60% salt marsh, 25% mudflat, and 15% other. Assuming the 15% of other habitat remains constant, the other scenario of one-half salt marsh and one-half mudflat consists of 42.5% salt marsh and 42.5% mudflat.

Habitat areas that are restored on-site will experience long-term evolution under future conditions of rising sea level, inputs/losses of sediment, and varying water quality. Considering the historic trends of rising sea level and loss of sediment, it is highly probable that vegetated salt marsh would be lost and converted to mudflat. Therefore it may be prudent to aim for establishment of the greatest proportion of vegetated salt marsh on-site, with the expectations that future losses will occur but that they are within an acceptable range of area. This approach would potentially create a buffer of vegetated salt marsh in anticipation of adverse future conditions for this habitat type.

While a primary project goal is to restore the extensive historic salt marsh habitat that once occurred in Parsons Slough, the cost of importing sediment limits the ability to achieve that goal. Additionally, other habitats that the area provides, including intertidal mudflats and soft subtidal habitats, provide valued ecosystem services.

Table 4-1 – Historic and Existing Habitat Proportions at the Parsons Complex

Habitat	Historic Percentage (Year 1870)	Existing Percentage (Year 2000)	Difference in Percentage
Generalized Habitat Types			
Freshwater/Riparian	2%	1%	-1%
Salt Marsh/Mudflat/Channel	98%	99%	+1%
Total	100%	100%	0%
Specific Habitat Types			
Subtidal	6%	9%	+3%
Mudflat	0%	81%	+81%
Vegetated Salt Marsh	92%	4%	-88%
Transitional/Upland/Freshwater	2%	6%	+4%
Total	100%	100%	0%

Source of the data: ESNERR 2009 (Eric Van Dyke).

Advantages of installing the maximum vegetated salt marsh with minimal mudflat include**:**

- The habitat mix would more closely resemble historic habitat proportions on-site;
- Greater reduction in tidal prism and tidal flow velocities compared to the other option that would benefit both the Parsons Complex and Elkhorn Slough (would also results in more frequent tidal flushing and potentially improved water quality); and
- A measure of buffer to vegetated marsh habitat would exist to anticipate future wetland losses during sea level rise.

Disadvantages of installing the maximum vegetated salt marsh with minimal mudflat include**:**

- Project costs are $6 million higher compared to the 50/50 habitat mix scenario;
- Greater impact to existing wetland by filling over larger areas (80 acres more) than the 50/50 habitat mix scenario; and
- Loss of mudflat and subtidal habitat that currently has high value to sharks and rays, shorebirds and harbor seals.

4.4.1.3. Salt Marsh Restoration at Alternate Sites

Additionally, this investigation revealed the existence of other subsided marsh areas where, because of the existing elevation, existing habitat functions and their proximity to sediment sources may provide more cost effective locations for large scale salt marsh restoration via sediment additions. Pick-N-Pull marsh, Seal Bend and Minhoto are three sites in closer proximity to sources of sediment at the Harbor and off shore.

4.4.2. Evaluate Feasibility of Sediment Additions

Future assessments need to occur regarding sediment addition. Initial investigations may need to focus on utilizing the granite dust and other sediment such as sediment in Monterey Bay or dredge materials presently disposed of there. Specifically, issues to resolve are environmental risk assessment, suitability determination, and delivery mode evaluation for sediment additions.

A priority for future planning includes evaluating options for sediment addition and salt marsh restoration. Four priority areas of investigation have been identified:

1. Collaborate with the Army Corps of Engineers and the Moss Landing Harbor District to characterize the suitability of Moss Landing harbor dredge materials for beneficial

reuse in marsh restoration. The next steps include evaluating sediment placement on former marshes as part of the risk assessment phase of future harbor dredge projects.

2. Build on the analysis in this report of sediment sources and approaches for sediment transport and containment to efficiently evaluate and plan the restoration of degraded tidal marsh sites elsewhere in Elkhorn Slough. Priority should be placed on those sites that are at a higher elevation, where a given quantity of sediment will restore a larger acreage of tidal marsh.

3. Evaluate the suitability of granite dust from the Graniterock quarry for tidal marsh and mudflat restoration by the use of trials that characterize, among other attributes, the colonization of the material by salt marsh vegetation and benthic invertebrates, potential changes in the chemistry and physical properties of the granite dust, potential effects associated with grain angularity, and invertebrate abrasion. Greenhouse, plot scale and/or demonstration scale (up to five acres) projects should be considered to evaluate performance at scales up to the size of the drainage network of a small tidal creek.

4. Evaluate whether sediment proposed for additions will require soil amendments for proper fertility and function. This assessment should prioritize consideration of practical construction issues, cost and the No-Amendment Alternative. Issues to consider in addition to feasibility include the type of amendment, method of incorporation, thickness of the surface cap and quantity of material added, the ratio of sediment, amendment and native mud.

4.4.3. Engineering Considerations for Tidal Marsh Restoration

The bed elevation of the Parsons Complex will only be raised to the elevation required for salt marsh restoration with significant sediment additions. Natural sediment supplies are very likely to be insufficient. This section and the section following focuses on the primary unresolved issue associated with the sediment addition alternatives. In particular, this section discusses the high cost of sediment addition, uncertainty about sediment quality, and uncertainty about the environmental effects of large scale sediment addition.

Designs for fill should envision raising the existing mudflat surfaces to an elevation of approximately +5 feet above MLLW to create vegetated marsh, while leaving existing channels in place without being filled. Sediment addition would be intended to create a three dimensional surface with no fill in existing channels, but fill at level areas that are presently mudflat to become vegetated salt marsh. Fill would occur between salt marsh and interior channel banks to create stable slopes transitioning from subtidal to salt marsh areas.

Fill could be delivered by various means. Trucks are appropriate for relatively small quantities. Water-based delivery using a pumped slurry line is the most cost-effective and environmentally-sensitive for large quantities. The slurry line could remain in place over the long-term. Sediment could be obtained from Graniterock Wilson Quarry as a fluidized granite dust and seawater mixture. That sediment may need to be amended once at the site or capped with marine sediment from local harbors to render it more suitable. Moss Landing Harbor and offshore and nearshore sediment sources may also be viable, although the environmental effects would need to be closely evaluated. Occasional large scale terrestrial projects may also generate fill in the necessary quantities. Chapter 3 discusses sediment sources in detail.

Containment dikes may be needed to retain the added sediment and reduce losses from re-suspension and re-mobilization by tidal currents and wind waves. There is the possibility of experimentally adding sediment with no containment dikes under certain circumstances to identify if uncontained fill can be successfully performed.

A primary activity of future planning will consist of the further evaluation of sediment sources and placement sites to maximize the creation of salt marsh with minimal environmental impacts and minimal costs. Sediment placement sites and the associated sediment containment structures were presented in Chapter 3. This section reviews those elements of restoration Alternatives 2 and 3 recommended for further investigation.

Additional preliminary engineering is typically required prior to being able to initiate environmental review and permitting. Preliminary engineering tasks would include concept design of the fill areas, containment dikes, the sill, the slurry delivery system (if that is the preferred option), perimeter access areas for land-based equipment and possibly batch plant sites, and possibly more numerical modeling of the sill to refine the design and quantify all potential effects to hydrodynamics, erosion/sediment, and water quality. Physical modeling of the sill in a hydraulics laboratory may also be useful to better replicate processes at a visible scale. Completion of additional engineering may take from six months up to one year. Specific additional studies that should be performed include the list below and possibly others:

- Analyze potential entrance channel headcutting;
- Identify the impacts to Elkhorn Slough of deferring tidal prism reduction until it can be accomplished using fill placement; and
- Determine the proportion of vegetated marsh to mudflat and subtidal area for restoration.

4.4.3.1. Tidal Marsh Restoration throughout the Parsons Slough Complex

Alternative 2 represents one course of action for long-term salt marsh restoration. The estimated construction cost for Alternative 2 is $50.4 million. The itemized construction cost estimate is provided in Appendix 4-A. As costs of this option are fairly high due to the large amounts of fill required for the entire site, it may be prohibitive to implement this as a single project. It may, however, be implemented over time as a series of fills. The proposed sediment addition areas of Alternative 2 are shown in Figure 4-5.

Depending on the availability of suitable material, sediment could be added to the entire Complex at one time or to individual areas over a long period of time. The volume of sediment needed to raise the entire Complex to the elevation appropriate for establishment of vegetated salt marsh is approximately 2.3 million cubic yards. Obtaining very large quantities of fill for the entire Parsons Complex is a major undertaking, with high costs and impacts to the environment. If only smaller fill volumes are added, incremental fills within smaller areas of the fingers and other areas could occur to create vegetated salt marsh habitat.

Filling may have to occur behind containment dikes to retain the sediment in place, particularly if it is in the form of a slurry containing suspended sediment that would need to settle out and deposit. The dikes enable the sediment to remain within a sheltered, low energy environment that is less directly affected by currents and wind waves. It may be possible to fill the site with no containment dikes if experimental fills in the absence of dikes show no appreciable sediment losses. Containment dikes are assumed to be constructed of marsh bed (mudflat) material scooped by a clamshell dredge (crane on a barge) as an initial task of sediment additions. It is possible to contain fills with only dikes and no culverts, depending on site hydraulics and properties of the fill (i.e. grain size). Culverts, since they would entail muting, have not been supported by the Parsons Restoration Team, except as a temporary measure.

4.4.3.2. Tidal Marsh Restoration in Portions of the Parsons Slough Complex

As an alternative to sediment additions throughout the Parsons Slough Complex, as described in Alternative 2, smaller sections could receive sediment additions instead, as described in Alternative 3. Alternative 3 represents possible short-term approach as it can achieve near-term salt marsh habitat creation. The decisions about the proper habitat distribution between channels, mudflats and salt marsh would during the planning process. Costs of this option are lower than Alternative 2 due to the reduced area of fill proposed and lack of a large structure.

Because of the limited availability of sediment, such an approach may be necessary even if the ultimate goal is to add sediment throughout the area.

The topography and bathymetry of the site would change under Alternative 3. The surface would retain existing channels, large level areas of fill would be placed within the mudflat areas of the fingers to become vegetated salt marsh. The estimated construction cost of Alternative 3 A-D (5) is $27.8 million if containment dikes are included as shown in Appendix 4-A.

The major restoration elements of Alternative 3 include sediment addition at the 6th Finger, the Five Fingers, South Marsh, and Rookery Lagoon. Figure 4-6 shows Alternative 3.

4.4.3.3. Site Selection for Sediment Additions

Subsequent restoration actions should focus on initiating sediment infilling in areas that will provide valuable monitoring data and be least costly to fill, yet will yield the greatest potential for measurable results of vegetated marsh creation. Choices exist for the initial filling location as the 6th Finger and the Five Fingers would provide significant, but different, advantages as being the first ones filled. Initial fill sites should probably be relatively small in scale, thus being limited in impact, cost, and effort as incremental steps toward restoration.

<u>The 6th Finger</u>

The site that yields maximum marsh creation and significant tidal prism reduction for the amount of fill placed is the 6th Finger. Adding sediment to the 6th Finger could potentially create a maximum area of new vegetated marsh habitat per every cubic yard of fill placed. Also, adding sediment to the 6th Finger could appreciably reduce the tidal prism.

The initial placements of sediment could be done by various means, including slurry line, rail, truck, or various combinations of these delivery modes. Since the 6th Finger is located east of the UPRR rail line it poses logistical challenges to construction and access using land-based equipment. Maximum flexibility for the ESNERR in filling the 6th Finger could be gained by providing an upland access route for construction equipment, while concurrently pursuing the other options of a water-based construction process (slurry line) and delivery by rail. As a test project, the costs to truck the material may be less than costs to set up a slurry or rail system.

The construction cost to completely fill the 6th Finger without tidal muting is estimated to be $2.1 million, including all construction components.

<u>The Five Fingers</u>

Filling of the Five Fingers presents the largest benefits for Goals 1 and 2 in the project, benefitting both the Parsons Complex and Elkhorn Slough. Placing fill would result in new marsh and will provide the maximum reduction in tidal prism.

However, sediment placement in the Five Fingers may conflict with Goal 3, preserving the highest quality fish habitat in Parsons Slough. Resolution of this conflict is required through a planning process that identifies the best use for the area. The Five Fingers are extensive, and it may be that both salt marsh restoration and fish habitat preservation could be achieved.

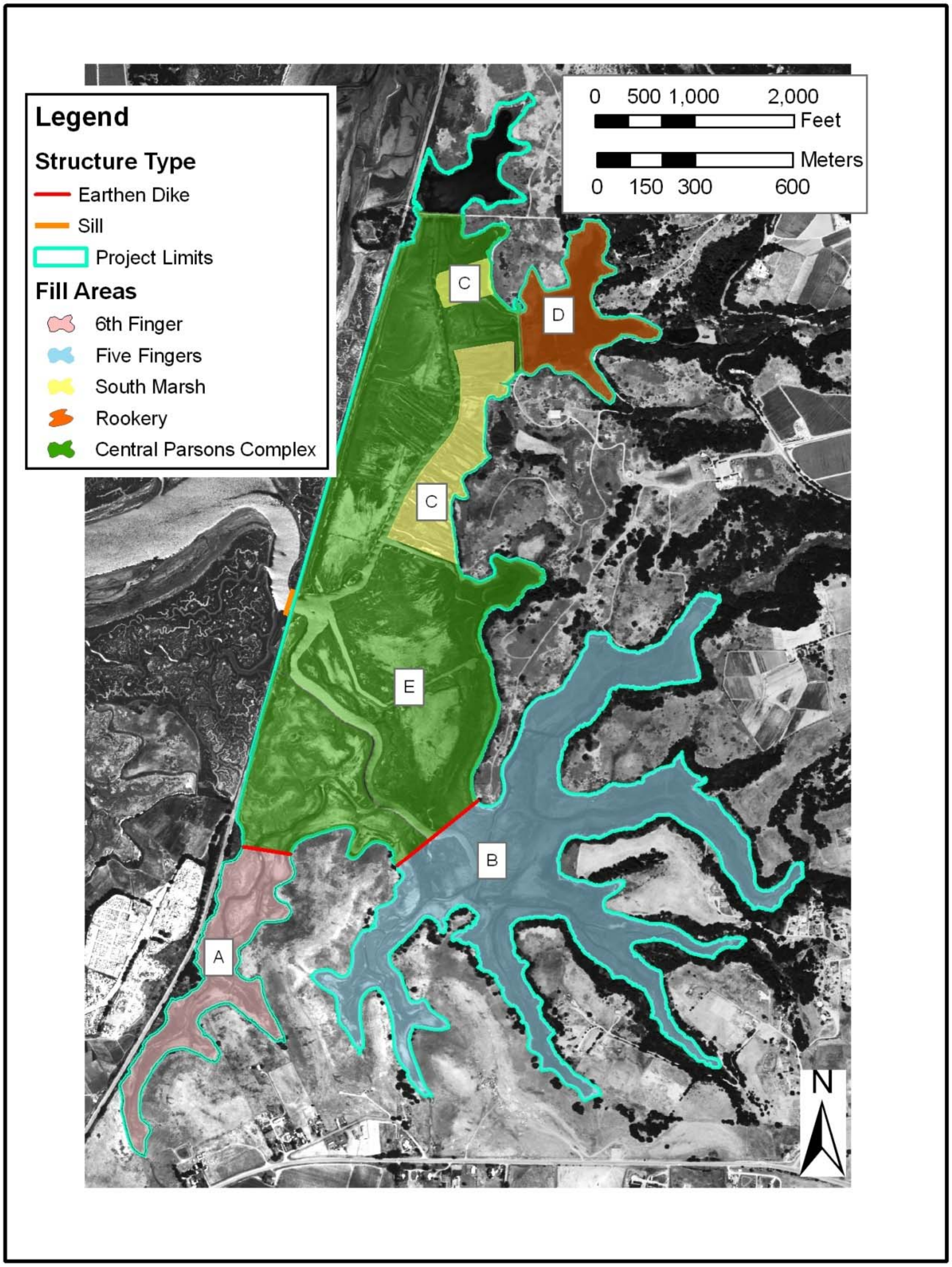

Figure 4-5 – Alternative 2 Fill Area

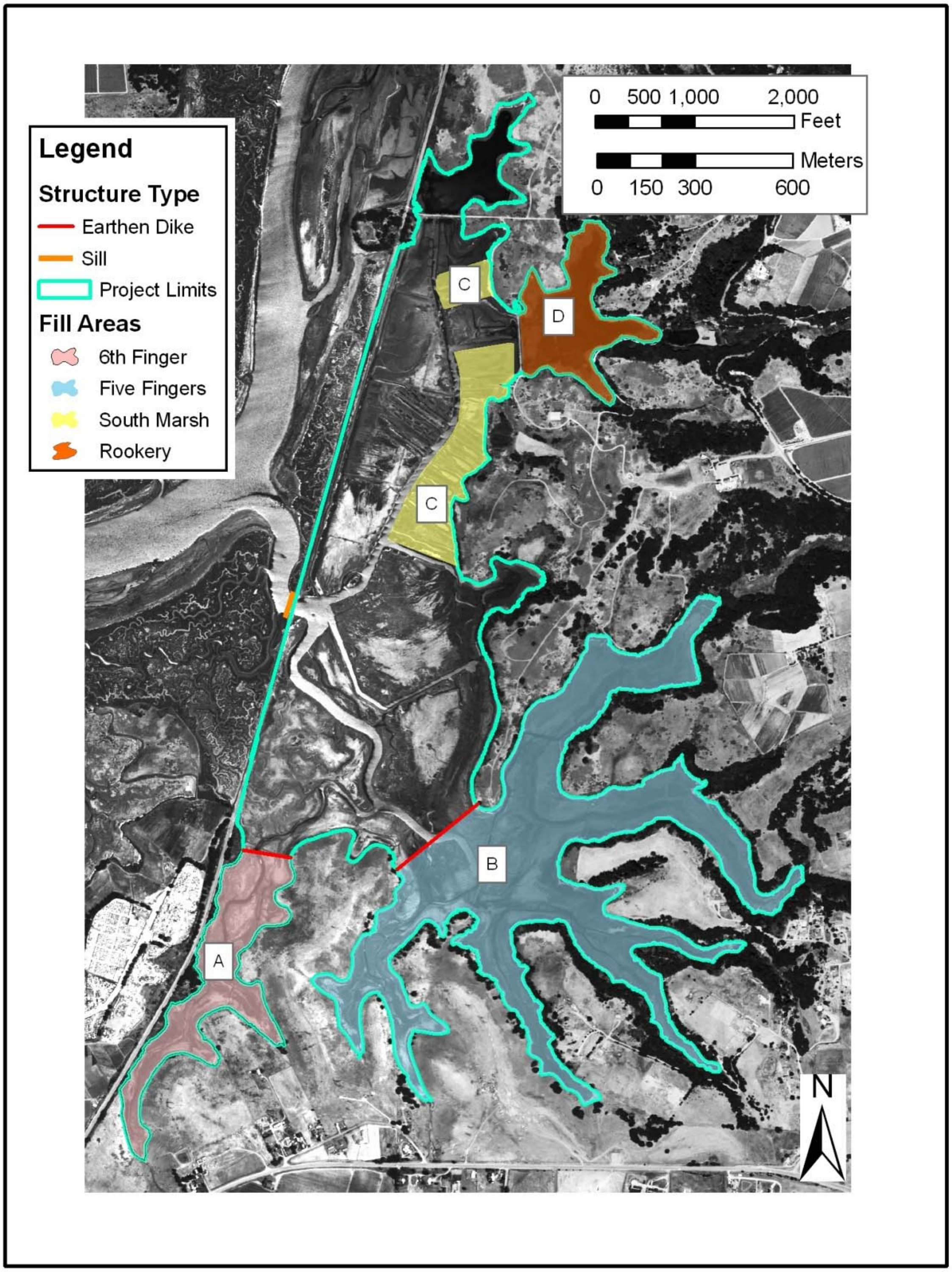

Figure 4-6 – Alternative 3 Fill Areas

The slurry line sediment delivery option is well-suited for filling the Five Fingers because it is difficult to access with land-based equipment. Water-based delivery of sediment to the site may be the most efficient option. If this were the option chosen for restoration, initial actions to implement the slurry line system would need to be investigated, planned, funded, and executed. This effort requires lead time and should be initiated as soon as possible by approaching strategic partners related to supplies of fill.

The construction cost to completely fill the Five Fingers without tidal muting is estimated to be $9.7 million, including all construction components.

South Marsh and the Rookery Lagoon

South Marsh and the Rookery would be of comparable priority to the Five Fingers, and has similar considerations with respect to existing habitat. Filling each area presents a similar level of benefit for creation of salt marsh and reduction of tidal prism. The Rookery lends itself better to trucking because there is access for land-based equipment so it could be done separately from other areas. South Marsh is assumed to be mainly limited to water-based work because there is no existing land-based access route. Installing a new construction route would potentially impact the terrestrial environment, although ESNERR staff have indicated that habitat at that location could possibly be disturbed without significant impacts (Woolfolk 2008).

The construction cost to completely fill the South Marsh restoration cells without tidal muting is estimated to be $3.0 million, including all construction components, and the cost to completely fill the Rookery is estimated to be $2.1 million.

Short-term actions of filling the areas discussed above would directly affect one-half of the Parsons Complex, or 229 acres out of a total of 460 acres. Also, the quantity of fill required to be added to create the target habitat scenario from short-term restoration is a total of 1.13 million cubic yards. The remaining area would be restored as part of long-term actions described below. Total costs of short-term actions are approximately $27.8 million. Assuming the long-term vision is to implement Alternative 2 with the sill and complete fill, the project cost is $50.4. The balance of the project costs would be incurred as part of long-term actions.

A final phase could be to fill the remaining central area in the Parsons Complex.

4.4.3.4. Cost Considerations

The section Cost/Benefit of alternatives in Chapter 3 describes the fill quantities, costs and benefits in terms of salt marsh restoration and tidal prism reduction associated with different sediment placement locations in the Parsons Slough Complex. This section should be referenced in future planning that considers the tradeoffs between restoring salt marsh to different areas inside and outside Parsons Slough. Two scenarios are summarized below, following a discussion of general considerations.

Itemized cost estimates to implement the project are presented in Appendix 4-A. The range of activities included in the cost estimates extend from only installing the sill, to installing the sill and entirely filling the site with sediment and utilizing containment dikes. A summary of the cost of each option is shown in Table 4-2 below. The least costly action is installing the sill, followed by the more cost actions of filling the site with sediment.

Table 4-2 – Estimated Construction Costs of Project Actions

PROJECT ACTION	ESTIMATED CONSTRUCTION COST
Install the Adjustable Sill Only	$3.9 Million*
Sill and Complete Fill With Containment Dikes	$50.4 Million
Sill and Complete Fill Without Containment Dikes	$48.6 Million
All Fills With Containment Dikes	$27.8 Million
All Fills Without Containment Dikes	$24.9 Million

* includes planning, engineering and regulatory compliance costs

The cost to restore the Parsons Complex to the maximum vegetated salt marsh scenario would be higher than for a lesser salt marsh area scenario. For example, the estimated cost to add sediment infill to the Complex to raise its elevation to create vegetated salt marsh under Alternative 2 is approximately $30 million for only the fill component. This cost is based on assuming a quantity of 2.3 million cubic yards of fill is needed to create 60% salt marsh at the site. The fill quantity could be reduced to create only 42.5% salt marsh. To estimate the reduction, it is assumed that the target elevation for mudflat is at +2 feet MLLW which is the elevation of the majority of existing mudflat on-site. The quantity of fill needed would be reduced from 2.3 to 1.8 million cubic yards as shown in the calculation in Appendix 4-B.

The construction cost estimate assumes amended sediment would cost $13 per yard, with 50% of the volume as sediment and 50% as soil amendment. Using this assumption, the cost to fill the Parsons Complex and achieve the 50/50 split habitat scenario would be $24 million. The cost savings to go from the maximum salt marsh scenario to the 50/50 habitat split scenario is approximately $6 million. This estimation is intended to show approximate order-of-magnitude cost changes from varying habitat types. More specific analyses should be performed using cost estimate spreadsheets shown in Appendix 4-A once habitat proportions are determined.

4.4.4. Approach Project Partners

The proposed restoration would require approval from Union Pacific Railroad to install the sill, and implement any sediment addition options such as a slurry line within the UPRR right-of-way. A first step will be to obtain UPRR approval of sill designs and installation. Also, acquiring land or permission to use their right-of-way could determine whether the slurry line option for adding sediment is feasible or too costly. Early coordination, information sharing and partnership-building should occur to pursue all project options.

Graniterock Wilson Quarry is a potential partner because they could provide the majority of the material for sediment additions. Access to their facility and connection to their system is required to cost-effectively pump sediment to the Parsons Complex. The Quarry staff also has experience with pumping their granite dust to a disposal location, and can provide valuable assistance and input on establishing the system. At some point a cost- and resource-sharing agreement would have to be implemented between the ESNERR and Quarry to install and operate the system. Coordination should also be initiated with the US Army Corps of Engineers, Moss Landing Harbor and the Monterey Bay National Marine Sanctuary to acquire access to other fill sources from the Harbor and nearshore environment in Monterey Bay.

4.4.5. Apply for Funding

Funding is required to advance this various projects. The Federal government awarded a grant of $3.9 million for the design and installation of the adjustable sill. Funding is required to continue the planning process for salt marsh restoration in Elkhorn Slough, including site selection and the evaluation of potential sediment sources, such as investigations of material properties, sediment placement field trials and demonstration projects. Funding would be required for design, regulatory compliance, installation and monitoring. Securing additional funding for future actions will typically require a long lead time item compared to other tasks, so applications should be submitted to appropriate sources as soon as a proposed project is identified. Funding applications may have to be ongoing to generate sufficient funds to fully implement the project if one large funding source does not become available.

4.4.6. Environmental Review

Environmental review is required for this project to satisfy the California Environmental Quality Act (CEQA). Environmental review of individual pilot projects would likely be conducted separately. Once a sediment addition approach was fully evaluated and selected, compliance could be conducted for a larger tidal marsh restoration project and all of its related components. The Initial Study performed as part of a previous task indicates an Environmental Impact Report

(EIR) may be appropriate for this project, but it could also potentially be approved under a Mitigated Negative Declaration if controversy is minimal and agencies concur with a reduced level of environmental review. For conservatism in planning, it is assumed that the appropriate document to satisfy the National Environmental Policy Act (NEPA) is an Environmental Impact Statement (EIS) roughly equivalent in detail to the EIR. A joint EIR/EIS may be the most appropriate document to prepare to address all issues comprehensively. Completion of the CEQA/NEPA process may take up to one and one-half years. Overall environmental impacts are assessed in a CEQA Initial Study presented in Appendix 4-C. The Lead Agency for CEQA could be the Department of Fish and Game, while the NEPA lead could be the ESNERR.

4.4.7. Permitting

Permits are required from various agencies with jurisdiction over the project area. Permit applications will need to be submitted to the following jurisdictional agencies at a minimum:

- County of Monterey – Coastal Development Permit;
- Regional Water Quality Control Board – See below:
  - Section 401 Water Quality Certification;
  - NPDES Permit;
  - Waste Discharge Requirements; and possibly a
  - Dewatering Permit.
- California Coastal Commission – Coastal Development Permit (if dredging and fill were to occur in the ocean and slough area outside of County jurisdiction);
- State Lands Commission – Lease of State Lands;
- Department of Fish and Game – Streambed Alteration Agreement;
- Pacific Gas and Electric – Landowner agreement to fill the upstream end of the 6th Finger; and
- U.S. Army Corps of Engineers – Sections 10 and 404 permit.

Securing all permits may require a time period of one year to one and one-half years.

4.4.7.1. Wetland Delineation

A formal wetland delineation will be necessary to secure permits and to quantify wetland area affected by proposed actions. The delineation is to be done according to State (California Department of Fish and Game and California Coastal Commission) and Federal (U.S. Army Corps of Engineers) wetland definitions and criteria. A wetland delineation could be completed within a month.

4.4.8. Final Engineering for Construction

Final engineering for construction is to be completed prior to construction starting, and could overlap and run concurrently to some extent with environmental review and permitting. This step is to generate engineering plans, construction specifications, and a construction cost estimate for each phase of the entire project. A bid package is also generated to solicit contractor bids to perform the work. Final engineering could take from six months up to one year to complete if submittals are required at multiple steps in the process, such as at 30%, 65%, 90%, and 100% of design progress.

4.4.9. Pre-Restoration Monitoring

Monitoring prior to restoration is occurring at the Parsons Complex and should obviously continue through construction and after construction. Monitoring should include parameters that may change after the project including habitat distribution and diversity, tidal prism, and wetland channel morphology. Pre-restoration monitoring will document the baseline values of the monitoring parameters that can be monitored after restoration and into the future to measure restoration success and enable adaptive management. Funding from NOAA in 2009 will provide support for pre-project monitoring of the site with respect to certain parameters such as dissolved oxygen, temperature and salinity.

4.4.10. Construction

When implementing sediment additions, it may be prudent to implement a pilot project for restoration on a smaller scale than the first phase, coupled with monitoring of invertebrate recruitment and habitat evolution to document effects and inform the larger project. Adjustments and corrective actions could be incorporated into the project design for construction of the larger project. Monitoring water quality and possibly other variables will need to occur during construction. Construction of the first phase could be accomplished in approximately one year minimum and 3.5 years maximum assuming a delivery rate of sediment of 1 million cubic yards per year (the production rate of the Quarry and the delivery capacity of the pumping system).

4.4.11. Post-Restoration Monitoring

On-going monitoring of tides, water quality, and habitat distribution and diversity will need to occur over the long-term to quantify changes. Monitoring data should be archived to the project GIS database and linked to the ESNERR website for public use. Results of monitoring data analyses should be reported on an annual basis to resource agencies over the first five full years after restoration of each phase. A longer monitoring period may be required if the system fails to develop in accordance with predicted conditions during the first five years, or ecosystem stability is not achieved during the first five years. The most important monitoring criteria are related to dissolved oxygen concentrations, which may be affected by the sill and/or fill placement in the Complex. Concentrations should be tracked at multiple locations near the surface and at depth.

4.4.12. Adaptive Management

Monitoring data will inform site management. Corrective actions may need to be taken as called for during the analyses of monitoring results to maintain the ecologic health of the site. A process and decision structure should be developed to interpret monitoring results and make management decisions in response. Natural dynamics will occur, but major problems or sensitive habitat losses would need to be addressed. Adaptive management may apply to modifications of the sill, or other features such as site elevations. If dissolved oxygen conditions worsen, modifications to the fill placement regime or sill geometry should be evaluated and implemented to minimize adverse conditions.

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APPENDIX 4-A – CONSTRUCTION COST ESTIMATES FOR ALTERNATIVES 2 AND 3

CONSTRUCTION COST ESTIMATE
Alt 2 - Sill and Complete Fill With Containment Dikes
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$500,000.00	$500,000
	Install Sill From the Water				
2	Rock core (less than 12 inch quarry run rock)	6,000	Ton	$60.00	$360,000
3	Rock armor (400 pound stone - 2 feet in diameter)	1200	Ton	$80.00	$96,000
4	Scour apron (400 pound stone aound base of weir, 10 feet out)	1,000	Ton	$80.00	$80,000
	Subtotal Sill				**$1,036,000**
5	Install Dike at 6th Finger - Rock core (less than 12 inch quarry run rock)	1	LS	$97,100.00	$97,100
6	Soil amendment	62,050	CY	$15.00	$930,750
7	Place Fill at 6th Finger	62,050	CY	$10.00	$620,500
	Subtotal 6th Finger				**$1,648,350**
8	Install Dike at Five Fingers - Rock core (less than 12 inch quarry run rock)	1	LS	$202,479.00	$202,479
9	Soil amendment	358,741	CY	$15.00	$5,381,108
10	Place Fill at Five Fingers	358,741	CY	$10.00	$3,587,405
	Subtotal Five Fingers				**$9,170,992**
11	Install Dikes at South Marsh - Rock core (less than 12 inch quarry run rock	1	LS	$700,413.00	$700,413
12	Soil amendment	71,167	CY	$15.00	$1,067,498
13	Place Fill at South Marsh	71,167	CY	$10.00	$711,665
	Subtotal South Marsh				**$2,479,576**
14	Soil amendment at Rookery	75,685	CY	$15.00	$1,135,275
15	Place Fill at Rookery	75,685	CY	$10.00	$756,850
	Subtotal Rookery				**$1,892,125**
16	Soil amdndment at All Other Areas	601,537	CY	$15.00	$9,023,055
17	Place Fill at All Other Areas	601,537	CY	$10.00	$6,015,370
	Subtotal All Other Areas				**$15,038,425**
	Subtotal Items				**$31,265,467**
	Contingency			25%	$7,816,367
	Permits			1.25%	$390,818
	Environmental Review (EIR for the entire wetlands complex)			1.25%	$390,818
	Final Engineering, Bid Documents, Construction Support			4.5%	$1,406,946
	Construction Management			3.0%	$937,964
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$8,190,633
	Subtotal Soft Costs				$19,133,547
	GRAND TOTAL				**$50,399,014**
	Cost Per Cubic Yard				$22

CONSTRUCTION COST ESTIMATE
Alt 2 - Sill and Complete Fill Without Containment Dikes
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$500,000.00	$500,000
	Install Sill From the Water				
2	Rock core (less than 12 inch quarry run rock)	6,000	Ton	$60.00	$360,000
3	Rock armor (400 pound stone - 2 feet in diameter)	1200	Ton	$80.00	$96,000
4	Scour apron (400 pound stone aound base of weir, 10 feet out)	1,000	Ton	$80.00	$80,000
	Subtotal Sill				**$1,036,000**
5	Soil amendment	62,050	CY	$15.00	$930,750
6	Place Fill at 6th Finger	62,050	CY	$10.00	$620,500
	Subtotal 6th Finger				**$1,551,250**
7	Soil amendment	358,741	CY	$15.00	$5,381,108
8	Place Fill at Five Fingers	358,741	CY	$10.00	$3,587,405
	Subtotal Five Fingers				**$8,968,513**
9	Soil amendment	71,167	CY	$15.00	$1,067,498
10	Place Fill at South Marsh	71,167	CY	$10.00	$711,665
	Subtotal South Marsh				**$1,779,163**
11	Soil amendment	75,685	CY	$15.00	$1,135,275
12	Place Fill at Rookery	75,685	CY	$10.00	$756,850
	Subtotal Rookery				**$1,892,125**
13	Soil amendment	601,537	CY	$15.00	$9,023,055
14	Place Fill at All Other Areas	601,537	CY	$10.00	$6,015,370
	Subtotal All Other Areas				**$15,038,425**
	Subtotal Items				**$30,265,475**
	Contingency			25%	$7,566,369
	Permits			1.25%	$378,318
	Environmental Review (EIR for the entire wetlands complex)			1.25%	$378,318
	Final Engineering, Bid Documents, Construction Support			4.0%	$1,210,619
	Construction Management			3.0%	$907,964
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$7,899,299
	Subtotal Soft Costs				$18,340,888
	GRAND TOTAL				**$48,606,363**
	Cost Per Cubic Yard				$21

Notes:
1. This alternative may be able to be constructed using silt curtains to retain fills in receiving areas rather than dikes.

CONSTRUCTION COST ESTIMATE
Alternative 3E - All Fills With Containment Dikes
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$500,000.00	$500,000
2	Install Dike at 6th Finger	1	LS.	$97,107.00	$97,107
3	Place Fill at 6th Finger	62,050	CY	$10.00	$620,500
4	Soil Amendment	62,050	CY	$15.00	$930,750
	Subtotal Construction at 6th Finger				**$2,148,357**
5	Mobilization & Demobilization	1	LS.	$500,000.00	$500,000
6	Install Dike at Five Fingers	1	LS.	$202,479.00	$202,479
7	Place Fill at Five Fingers	358,741	CY	$10.00	$3,587,405
8	Soil Amendment	358,741	CY	$15.00	$5,381,108
	Subtotal Construction at Five Fingers				**$9,670,992**
9	Mobilization & Demobilization	1	LS.	$500,000.00	$500,000
10	Install Dikes at South Marsh	1	LS	$700,413.00	$700,413
11	Place Fill at South Marsh	71,167	CY	$10.00	$711,665
12	Soil Amendment	71,167	CY	$15.00	$1,067,498
	Subtotal Construction at South Marsh				**$2,979,576**
13	Mobilization & Demobilization	1	LS.	$250,000.00	$250,000
14	Place Fill at the Rookery	75,650	CY	$10.00	$756,500
15	Soil Amendment	75,650	CY	$15.00	$1,134,750
	Subtotal Construction at Rookery				**$2,141,250**
	Subtotal Items				**$16,940,174**
	Contingency			25%	$4,235,044
	Permits			1.75%	$296,453
	Environmental Review (EIR for the entire wetlands complex)			1.75%	$296,453
	Final Engineering, Bid Documents, Construction Support			5.0%	$847,009
	Construction Management			4.0%	$677,607
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$4,520,010
	Subtotal Soft Costs				$10,872,575
	ALTERNATIVE 3E (5) GRAND TOTAL				**$27,812,749**
	Cost Per Cubic Yard				$12

CONSTRUCTION COST ESTIMATE
Alternative 3E - All Fills Without Containment Dikes
PARSONS COMPLEX RESTORATION PLAN

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$250,000.00	$250,000
2	Place Fill at 6th Finger	62,050	CY	$10.00	$620,500
3	Soil Amendment	62,050	CY	$15.00	$930,750
	Subtotal Construction at 6th Finger				**$1,801,250**
4	Mobilization & Demobilization	1	LS.	$250,000.00	$250,000
5	Place Fill at Five Fingers	358,741	CY	$10.00	$3,587,405
6	Soil Amendment	358,741	CY	$15.00	$5,381,108
	Subtotal Construction at Five Fingers				**$9,218,513**
7	Mobilization & Demobilization	1	LS.	$250,000.00	$250,000
8	Place Fill at South Marsh	71,167	CY	$10.00	$711,665
9	Soil Amendment	71,167	CY	$15.00	$1,067,498
	Subtotal Construction at South Marsh				**$2,029,163**
10	Mobilization & Demobilization	1	LS.	$250,000.00	$250,000
11	Place Fill at the Rookery	75,650	CY	$10.00	$756,500
12	Soil Amendment	75,650	CY	$15.00	$1,134,750
	Subtotal Construction at Rookery				**$2,141,250**
	Subtotal Items				**$15,190,175**
	Contingency			25%	$3,797,544
	Permits			1.75%	$265,828
	Environmental Review (EIR for the entire wetlands complex)			1.75%	$265,828
	Final Engineering, Bid Documents, Construction Support			5.0%	$759,509
	Construction Management			4.0%	$607,607
	Escalation (3% per year for 6 years, project assumed start date is 2014)			3% per year	$4,053,071
	Subtotal Soft Costs				$9,749,387
	ALTERNATIVE 3E (5) GRAND TOTAL				**$24,939,562**
	Cost Per Cubic Yard				$11

Notes:
1. This alternative may be able to be constructed using silt curtains to retain fills in receiving areas rather than dikes.
2. If no dikes are needed, mobilization costs would be lower than the scenario requiring dike construction.

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APPENDIX 4-B – ESTIMATE OF VOLUME REDUCTION AND COST SAVINGS FOR THE 50/50 HABITAT REDUCTION OPTION

The reduction in material quantity needed to restore habitat elevations between salt marsh and mudflat from a 50/50 habitat is presented below.

> +5.5 feet MLLW (average elevation of vegetated marsh) - +2 feet MLLW (average elevation for mudflat) = 3.5 feet of fill.

The area of this fill reduction is calculated as follows:

Alternative 2 vegetated salt marsh area = 276 acres (representing 60% of the site);

The 50/50 scenario of vegetated salt marsh area = 196 acres (representing 42.5% of the site); the difference between these areas is: 276 acres – 196 acres = 80 acres. The 80-acrea area can be converted to square feet by:

> 80 acres X 43,560 square feet per acre = 3,463,020 square feet, or approximately 3.5 million square feet.

The reduction in the quantity of fill to create the 50/50 split habitat scenario is therefore:

> 3.5 feet of fill X 3,500,000 square feet in area = 12,250,00 cubic feet, or 453,704 cubic yards, or approximately 454,000 cubic yards.

The reduced quantity of fill to create the 50/50 habitat split scenario is estimated as:

> 2,300,000 cubic yards – 454,000 cubic yards = 1,846,000 cubic yards.

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APPENDIX 4-C – CEQA INITIAL STUDY CHECKLIST FOR IMPLEMENTATION OF BOTH FILL PLACEMENT AND SILL INSTALLATION

(NOTE: This CEQA Initial Study Checklist is provided for illustrative purposes only. The project analyzed has not been recommended for implementation.)

ENVIRONMENTAL CHECKLIST FORM

1. Project Title: Alternative 2: Large Scale Sediment Placement and Subsequent Sill Installation to Restore Tidal Marsh for the Persons Complex

2. Lead Agency Name and Address:

3. Contact Person and Telephone Number:

4. Project Location: The Parsons Complex is located on the southeastern side of Elkhorn Slough on the edge of Monterey Bay between Santa Cruz and Monterey in central California.

5. Project Sponsor's Name and Address:

Elkhorn Slough National Estuarine Research Reserve

1700 Elkhorn Road

Watsonville, CA 95076

6. General Plan Designation: Rural Land

7. Zoning: Resource Conservation

8. Description of Project:

The vision for restoration of the Parsons Complex assumes a full tidal wetland ecosystem with the largest component of salt marsh possible, given existing and future constraints (that are physical, economic, environmental, and social in nature). Restoration will be accomplished by infilling the Complex with suitable sediment. Restoration will be phased over time and ultimately a sill may be constructed at the UPRR Bridge to retain the sediment.

Short-term restoration components consist of diking and filling of the fingers and other appropriate areas using sediment available from a local quarry and other potential sources. They will provide the following benefits:

- Immediate vegetated marsh benefits;
- Proof of concept for sediment addition using available fill;
- Generate momentum by accomplishing visible accomplishments rapidly; and
- Fundable component projects.

The main drawback to phasing the approach is that it accomplishes an approximate 30% reduction of the tidal prism, and delays the remaining 19% tidal prism reduction (total tidal prism reduction of 49%) until a sill is installed and ultimate fills are implemented.

Short-term restoration actions would be monitored for their effects, and assessed with regard to possible subsequent long-term restoration actions. If deemed appropriate from monitoring results, long-term actions could be taken to progress toward complete restoration of the complex. Long-term actions would consist of possibly installing a sill at the main entrance channel and infilling central marsh areas between the sill and the fingers. A more detailed discussion of each project and its respective actions is presented below.

8.1 Short-Term Restoration Actions

Short-term restoration projects can focus on initiating sediment infilling in areas that will provide valuable monitoring data and are least costly to fill, yet will yield the greatest potential for measurable results of vegetated marsh creation. Choices exist for the initial filling location as two sites that would provide significant, but different, advantages as being the first ones filled. Initial fill sites should probably be relatively small in scale, thus being of limited impact, cost and effort as incremental steps toward restoration.

Priority of Sediment Infilling

The 6th Finger

The site that yields maximum marsh creation and tidal prism reduction for the amount of fill placed is the 6th Finger. Adding sediment to the 6th Finger could potentially create a maximum of approximately 9.5 square feet of new vegetated marsh habitat per every cubic yard of fill placed. The likely habitat area created will be less than this ideal ratio as soil conditions and the environmental response of the marsh may not be of maximum efficiency, but this site provides the greatest probability of measurable new marsh habitat creation from infilling. Also, adding sediment to the 6th Finger could potentially reduce the tidal prism by 19 cubic feet for each cubic yard of sediment added.

The first initial placements of sediment could be done by various means, including slurry line, rail, truck, or various combinations of these delivery modes. Since the 6th Finger is located east of the UPRR rail line it poses logistical challenges to construction and access using land-based equipment. Maximum flexibility for the ESNERR in filling the 6th Finger could be gained by providing an upland access route for construction equipment, while concurrently pursuing the other options of a water-based construction process (slurry line) and delivery by rail. As a test project, the costs to truck the material may be less than costs to set up a slurry or rail system.

Five Fingers

Depending on the funding status of the project, the next area that should be filled is the Five Fingers. Filling of the Five Fingers presents the largest benefits to both Parsons and Elkhorn from any action of this restoration plan. Placing fill will result in 5.2 square of new marsh created for every cubic yard of sediment added, and will reduce the tidal prism by 21 cubic feet (a very efficient ratio of cubic feet of fill added to tidal prism reduced).

A particular order of filling of the Five Fingers is not yet determined, and should be considered by further study. The study should address if the fingers should be filled individually or as a whole. It may be that there is no clear difference between filling certain fingers before others, or the area as a whole since that operation is large-scale and will likely result in all the fingers being filled close in time to one another anyway. If the funding is available to fill the Five Fingers, it would be most efficient to fill the entire area as part of one large construction project.

South Marsh and the Rookery

South Marsh and the Rookery should also be filled, and the order of their work may depend on available funding. Filling each area presents a similar level of benefit for creation of salt marsh and reduction of tidal prism. However, South Marsh is a larger operation and requires a larger budget, while the Rookery is a smaller area needed a smaller budget. The Rookery lends itself better to trucking because there is access for land-based equipment so it could be done separately from other areas. South Marsh is limited to water-based work because there is no ready land-based access.

Short-term actions would directly affect one-half of the Parsons Complex, or 229 acres out of a total of 460 acres. Also, the quantity of fill required to be added to create the target habitat scenario from short-term restoration is a total of 1.13 million cubic yards. The remaining area would be restored as part of long-term actions described below. The balance of the project costs would be incurred as part of long-term actions. The short-term restoration phase costs nearly the double the long-term restoration phase because of the extent of containment diking required to install and retain individual fills.

8.2 Long-Term Restoration Actions

Long-term restoration actions can be focused on installing features that would be required to achieve full tidal restoration over the entire Parsons Complex, consisting of the sill and infilling of the remaining undiked central area in the Complex. The remaining area of the Parsons Complex to be filled is 231 acres with a total of 1.16 million cubic yards of sediment. The costs for this final set of actions is less than the short-term actions is because no internal diking is needed when filling the remainder of the Parsons Complex if the sill is in place to retain sediment after placement.

Install the Sill

The sill as designed will retain sediment placed within the Parsons Complex, and in so doing will allow formation of a modified geomorphic condition that will significantly reduce the tidal prism while increasing habitat. Reduced tidal prism in the Parsons Complex will result in reduced tidal scour and erosion within Parsons and within Elkhorn Slough.

If the design of the sill remains as is, it could be installed before any other restoration actions, but it can also be deferred until after short-term restoration actions are complete. At the latest, it is strongly recommended that the sill be implemented as the first long-term restoration action. In that context, the sill will serve to retain sediment added to the central undiked area of Parsons and allow for the remaining 231 acres of the Complex to be filled. A set of pros and cons of installing the sill are provided below.

Install the Remainder of the Fill

The remaining undiked areas of the central Parsons Complex would be filled at this stage. Approximately 1.16 million cubic yards of fill would be placed over approximately 231 acres of marsh area. The material could most effectively be placed using water-based construction such as the slurry line. It could be transported to the site using rail as well as slurry line.

9. Surrounding Land Uses and Setting: Rural

10. Other public agencies whose approval is required (e.g., permits, financing approval, or participation agreement.):

California Department of Fish and Game

U.S. Army Corps of Engineers

Regional Water Quality Control Board

California Coastal Commission

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED

The environmental factors checked below would be potentially affected by this project, involving at least one impact that is a "Potentially Significant Impact" as indicated by the checklist on the following pages.

☑ Aesthetics	☑ Hazards/Hazardous Materials	☐ Public Services
☐ Agriculture Resources	☑ Hydrology/Water Quality	☑ Recreation
☑ Air Quality	☐ Land Use and Planning	☑ Transportation and Traffic
☑ Biological Resources	☐ Mineral Resources	☐ Utilities and Service Systems
☑ Cultural Resources	☑ Noise	☐ Mandatory Findings of Significance
☐ Geology and Soils	☐ Population and Housing	

Determination

On the basis of this evaluation:

☐ I find that the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

☐ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. A MITIGATED NEGATIVE DECLARATION will be prepared.

☐ I find that the proposed project MAY have a significant effect on the environment, and an ENVIRONMENTAL IMPACT REPORT is required.

☐ I find that the proposed project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect 1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and 2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An ENVIRONMENTAL IMPACT REPORT is required, but it must analyze only the effects that remain to be addressed.

☐ I find that although the proposed project could have a significant effect on the environment, because all potentially significant effects (a) have been analyzed adequately in an earlier EIR or NEGATIVE DECLARATION pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier EIR or NEGATIVE DECLARATION, including revisions or mitigation measures that are imposed upon the proposed project, nothing further is required.

Signature	Date
Printed Name	Agency

I. AESTHETICS

a) Would the project have a substantial adverse effect on a scenic vista?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

During construction, equipment and vehicles will temporarily degrade the view in the construction area. After completion of each construction event, the view will be native habitat similar to the existing condition.

b) Would the project substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project would convert subtidal and mudflat habitat to tidal salt marsh. The proposed change in habitat type would not damage scenic resources.

c) Would the project substantially degrade the existing visual character or quality of the site and its surroundings?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

During construction, equipment and vehicles will temporarily degrade the view in the construction area. After completion of each construction event, the view will be native habitat similar to the existing condition.

d) Would the project create a new source of substantial light or glare, which would adversely affect day or nighttime views in the area?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

If construction occurs at night, light and glare could adversely affect nighttime views. This impact can be mitigated to insignificant by directing lights downward into the construction area and using the minimum amount of light necessary for construction.

II. AGRICULTURE RESOURCES

a) Would the project convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project would not convert farmland to non-agricultural use. The project is entirely within tidal waters.

b) Would the project conflict with existing zoning for agricultural use, or a Williamson Act contract?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project would occur entirely within tidal waters and would not affect agricultural uses.

c) Would the project involve other changes in the existing environment, which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project would occur entirely within tidal waters and would not affect agricultural uses.

III. AIR QUALITY

a) Would the project conflict with or obstruct implementation of the applicable air quality plan?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The Project will restore wetlands and would not involve growth-inducing impacts or cause an exceedance of established population or growth projections. With the included mitigation discussed below, the project would not create either short- or long-term significant quantities of criteria pollutants. The Project would not result in significant localized air quality impacts. As such, the Project is consistent with the goals of the 2008 Air Quality Management Plan (AQMP) for the Monterey Bay Air Basin. No impact would occur.

b) Would the project violate any air quality standard or contribute substantially to an existing or projected air quality violation?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

Restoration of wetlands will involve occasional use of construction equipment to bring in suitable fill material to compensate for tidal erosion. This fill material will be brought in gradually over several years with periods of fill activities followed by dormant times. At the height of the fill activities as much as 200 cubic yards of material may be imported and worked into the restoration area per day. That amount of fill will require approximately 10 truckloads to be imported to the site with 2 dozers, 2 loaders, and a water truck working 8 hours a day. This level of activity would create approximately 59 pounds of nitrous oxide, 6.43 pounds of reactive organic compounds (ROG), 31,5 pounds of carbon dioxide (CO), 177.68 pounds of fine particulate matter (PM_{10}) and 38.99 pounds of ultra-fine particulate matter ($PM_{2.5}$) per day. Considering these quantities of emissions PM_{10} exceeds the 82 pounds per day threshold set by the Monterey Bay Unified Air Pollution Control District (District) and mitigation to reduce fugitive dust is needed. The following mitigation will reduce PM_{10} emissions to below a level of significance:

AQ-1 All active areas and any unpaved haul routes that are not saturated shall be watered a minimum of twice daily.

AQ-2 All material being loaded and unloaded by equipment will be watered often enough to eliminate visible plumes of dust.

AQ-3 On unpaved roads, construction traffic speeds will be reduced to 15 mph.

With these mitigation measures in place PM_{10} emissions are reduced to 56.14 pounds per day and $PM_{2.5}$ emissions are reduced to 13.61 pounds per day. This level of emissions is below the threshold levels set by the District and impacts are less than significant.

c) Would the project result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state AAQS (including releasing emissions, which exceed quantitative thresholds for ozone precursors)?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

The project-specific evaluation of emissions presented above supports a conclusion that with mitigation the air quality impacts for the proposed project are less than significant on an individual project basis. CEQA Section 21100 (e) addresses evaluation of cumulative effects allowing the use of approved land use documents in a cumulative impact analysis. CEQA Guidelines Section 15064 (i)(3) further stipulates that for an impact involving a resource that is addressed by an approved plan or mitigation program, the lead agency may determine that a project's incremental contribution is not cumulatively considerable if the project complies with the adopted plan or program. In addressing cumulative effects for air quality, the AQMP is the most appropriate document to use because the AQMP sets forth a comprehensive program that will lead the air basin, including the project area, into compliance with all federal and state air quality standards and utilizes control measures and related emission reduction estimates based upon emissions projections for a future development scenario derived from land use, population, and employment characteristics defined in consultation with local governments. Since the proposed project is in conformance with the AQMP and the project is not significant on an individual basis, it is appropriate to conclude that the project's incremental contribution to criteria pollutant emissions is not cumulatively considerable.

d) Would the project expose sensitive receptors to substantial pollutant concentrations?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

With mitigation to reduce fugitive dust, project generated emissions are below the thresholds of significance. These emissions will dissipate and dilute with distance from the emission source. Sensitive receptors such as residential uses, hospitals or schools are not close the restoration area. The nearest sensitive receptors are rural, single-family homes, the closest of which is approximately 250 feet from the restoration activities when the equipment is at its closest point to this home. Considering the amount of emissions, the temporal nature of the activities, and the dissipation of emissions with distance, the Project is not anticipated to expose sensitive receptors to substantial pollutant concentrations and impacts are less than significant.

e) Would the project create objectionable odors affecting a substantial number of people?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The Project would involve the use of heavy equipment creating exhaust pollutants from on-site earth movement and from equipment bringing fill material to the site. With regards to nuisance odors, any air quality impacts will be confined to the immediate vicinity of the equipment itself. By the time such emissions reach any sensitive receptor sites away from the project site, they will be diluted to well below any level of air quality concern. An occasional "whiff" of diesel exhaust from trucks accessing the site from public roadways may result. Such brief exhaust odors may be adverse, but not a significant air quality impact. Additionally, some odor would be produced from the application of asphalt, paints, and coatings. Again, any exposure of the general public to these common odors would be of short duration and while potentially adverse, are less than significant.

IV. BIOLOGICAL RESOURCES

a) Would the project have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☑	☐	☐	☐

Construction activities have the potential to disturb sensitive species. Listed aquatic species that may be in the fill areas include the State and Federal endangered California brown pelican, the Federal threatened western snowy plover, the State and Federal endangered California least tern and the Federal threatened southern sea otter. Construction vehicles accessing the fill areas or working in terrestrial habitat have the potential to disturb sensitive plant species including the Federal threatened Monterey spineflower and the Federal endangered Yadon's rein orchid as well as non-listed plant species considered sensitive by the California Native Plant Society. Construction impacts to sensitive species could be reduced to insignificant by pre-construction surveys for sensitive plants and habitats to identify access routes and work areas that would avoid sensitive terrestrial resources. In addition, a biological monitor should be present during construction operations to minimize disturbance of resting and foraging activities of sensitive aquatic animals such as the southern sea otter.

The proposed fill operations will convert subtidal and mudflat habitat to salt marsh. Therefore sensitive marine animals including brown pelicans, snowy plovers, least terns and sea otters will suffer a long-term loss of habitat. However, the objective of the proposed fill is to restore the Parsons Complex to a more balanced mix of natural habitats. Because least terns and California brown pelicans do not breed in the area, loss of a small amount of foraging and resting habitat would be less than significant. Loss of mudflat and subtidal habitat is a potentially significant impact to southern sea otters and western snowy plovers, which do bred in the vicinity of Elkhorn Slough..

b) Would the project have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, and regulations or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☑	☐	☐	☐

The proposed project would result in a net loss of mudflat and subtidal channel habitat. Tidal mudflat and estuarine channels are considered valuable and sensitive habitats by the California Department of Fish and Game and the U.S. Fish and Wildlife Service. However, salt marsh, which has suffered substantial losses in the Parsons Complex due to erosion, is also considered a valuable and sensitive habitat by these agencies. The conversion of mudflat and subtidal habitat to salt marsh would restore balance and ecosystems functions that have been lost within the Parsons Complex and in Elkhorn Slough as a whole. The proposed fill also would reduce erosion and reduce the continued degradation of wetlands habitat in the area.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
c) Would the project have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☑	☐	☐	☐

The proposed project would convert subtidal and intertidal mudflat habitats, which are protected under Section 404 of the Clean Water Act, to tidal salt marsh, which also is protected under Section 404. Salt marsh habitat is classified as wetlands while subtidal channel and mudflat habitat fall under the category of Other Waters of the United States. The conversion of mudflat and subtidal habitat to salt marsh would restore balance and ecosystems functions that have been lost within the Parsons Complex and in Elkhorn Slough as a whole. The proposed fill also would reduce erosion and reduce continued degradation of wetlands habitat in the area.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
d) Would the project interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☑	☐	☐	☐

The proposed fill would result in a net loss of channel and mudflat habitat that is used as a nursery area for thornback rays and leopard sharks.

e) Would the project conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would restore ecological balance to the Parsons Complex by converting subtidal channel and mudflat to salt marsh and reversing the effects of erosion.

f) Would the project conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would restore ecological balance to the Parsons Complex by converting subtidal channel and mudflat to salt marsh and reversing the effects of erosion.

V. CULTURAL RESOURCES

A record search for the project area has not been conducted. During the CEQA review process this records search will be required, unless existing relevant information is available.

a) Would the project cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

If the records search and history of the area is indicative of potential for resources, the area must be surveyed for cultural resources before project impacts to historical resources can be assessed.

b) Would the project cause a substantial adverse change in the significance of an archaeological resource pursuant to §15064.5?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

If the records search and history of the area is indicative of potential for resources, the area must be surveyed for cultural resources before project impacts to historical resources can be assessed.

c) Would the project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

If the records search and history of the area is indicative of potential for resources, the area must be surveyed for paleontological resources before project impacts to historical resources can be assessed.

d) Would the project disturb any human remains, including those interred outside of formal cemeteries?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

It is unlikely that the area contains human remains interred outside formal cemeteries. However, the potential for human remains will need to be determined during the CEQA process.

VI. GEOLOGY AND SOILS

a) Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

Monterey County is located on active geologic fault lines. The most active fault is the San Andreas fault line that runs through the community of Parkfield, north of Moss Landing. The proposed project would convert mudflat and subtidal channel to salt marsh and would not expose persons or structures to the adverse effects of an earthquake greater than the present condition.

ii) Strong seismic ground shaking?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project would not expose people or structures to strong ground shaking greater than what currently exists.

iii) Seismic-related ground failure, including liquefaction?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The Parsons Complex is within an area of high liquefaction potential but the proposed project would not expose people or structures to liquefaction potential any greater than the existing condition.

iv) Landslides?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would fill subtidal and mudflat habitat to convert these areas to salt marsh and would not increase the potential for landslides in the project area.

b) Would the project result in substantial soil erosion or the loss of topsoil?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

The proposed project would place fill in areas that are currently being eroded. Therefore, the proposed project would help to offset the effects of erosion.

c) Would the project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction or collapse?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project is in an area of eroding soils and would help to offset the impacts of erosion on tidal habitats. There are no inhabitat structures on the fill sites and the filling of these areas would not subject people or structures to any impacts from ground movement that do not already exist.

d) Would the project be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

Because no structures other than an underwater sill are proposed as part of this project, the Uniform Building Code would not apply. No significant risks to life or property would occur as a result of this project.

e) Would the project have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would not require water or sewer service, septic tanks, or alternative waste water disposal.

VII. HAZARDS AND HAZARDOUS MATERIALS

a) Would the project create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

Some hazardous materials, such as diesel fuel, would be used at the site during construction. The transport of hazardous materials is regulated by the State and the transport of such materials to the site would be in compliance with all State regulations. These materials would only be present during construction and would be removed upon completion of the project. With Best Management Practices, impacts from construction-related spills of hazardous materials are considered less than significant.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
b) Would the project create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☑	☐	☐

Some hazardous materials, such as diesel fuel, would be used during construction. These materials would only be present during construction and would be removed upon completion of the project. With Best Management practices, impacts from construction-related spills of hazardous materials are considered less than significant.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
c) Would the project emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☑

There are no schools located within one-quarter mile of the proposed project. No impacts would occur.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
d) Would the project be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☐	☑

The proposed project is not on a list of known hazardous materials sites

e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project site is not located within an airport land use plan, or within two miles of a public or private airport.

f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project site is not located within the vicinity of a private airstrip.

g) Would the project impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

Project activity would not alter emergency response or emergency evacuation routes. The project site is within unoccupied tidal wetlands Roadways would not be blocked during construction or operation.

h) Would the project expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

The proposed project would not involve the construction of any structures. There is a very slight chance that during construction, workers would be exposed to fires that could start on wild land. Development of an emergency evacuation plan and other emergency measures in the case of fires would reduce risk of fire to workers to less than significant.

VIII. HYDROLOGY AND WATER QUALITY

a) Would the project violate any water quality standards or waste discharge requirements?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

The potential exists for water quality to be degraded temporarily during construction. The addition of sediment would temporarily result in a localized increase in turbidity. Vehicles and other construction equipment have the potential to leak or spill fuels into project waters. The implementation of turbidity control measures and standard Best Management Practices would reduce water quality impacts during construction to less than significant.

After sediment has settled, the proposed project would not degrade water quality. In the long-term, the ultimate build-out of the proposed project with large-scale fills would result in a shorter residence time for tidal waters in the Parsons Complex and an improvement in water quality over the existing condition.

b) Would the project substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would not impact groundwater recharge.

c) Would the project substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or offsite?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

The proposed project would add fill to tidal waters to increase salt marsh habitat. The project would reduce the impacts of existing erosion in the Parsons Complex. The proposed project would increase on-site siltation, but this increase in sediment would be beneficial and is the purpose of the project. The proposed project would not have an adverse effect on siltation or erosion off-site.

d) Would the project substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or offsite?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

The proposed project would add fill to tidal wetlands and would not increase surface run-off. The proposed project would not change tidal elevations from existing conditions.

e) Would the project create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project lies entirely within tidal waters. It would not contribute runoff to existing or planned stormwater drainage systems and it would provide not additional source of pollutants.

f) Would the project otherwise substantially degrade water quality?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

As discussed under a), the only potential degradation of water quality would be during construction. After fill events, the water quality would be similar to the existing conditions and at ultimate build-out would be better than the existing condition.

g) Would the project place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project does not involve housing.

h) Would the project place, within a 100-year flood hazard, area structures that would impede or redirect flood flows?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The only structure that would be constructed would be an underwater sill at ultimate build out.

i) Would the project expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project involves fill within tidal areas and, at ultimate build-out, potentially an underwater sill near the UPRR Bridge. No levees or dams would be jeopardized by the project. The sill, if built, would have a neutral or beneficial effect on the UPRR bridge because increased sedimentation under the structure in the entrance channel should fill existing scour areas, increase protection to the bridge piles and increase the integrity of the structure. The sill should not affect the railroad levee because high tides would not be muted and water levels would still reach maximum elevations on both sides of the levee.

j) Would the project expose people to inundation by seiche, tsunami, or mudflow?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would occur entirely within tidal waters and would not expose people to inundation by seiche, tsunami, or mudflow. No structures that would be occupied by people would be constructed as part of this project.

IX. LAND USE AND PLANNING

a) Would the project physically divide an established community?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would occur entirely within tidal wetlands. It would have no effect on any established community.

b) Would the project conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project site is within rural land zoned for resource conservation. The proposed restoration of salt marsh would not change the nature of the project area and would be compatible with existing land uses and policies.

c) Would the project conflict with any applicable habitat conservation plan or natural community conservation plan?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would convert subtidal channels and mudflat habitats to salt marsh. The conversion of one type of tidal habitat to another would restore balance and wetlands functions to the ecosystem. The project would not conflict with any habitat conservation or natural community conservation plan.

X. MINERAL RESOURCES

a) Would the project result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project would convert tidal channel and intertidal mudflat habitat to salt marsh. There would be no effects on any mineral resource.

b) Would the project result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The project would convert tidal channel and intertidal mudflat habitat to salt marsh. There would be no effects on any mineral resource.

XI. NOISE

a) Would the project result in exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

The proposed project would not result in any permanent elevation of noise levels. Noise would be limited to temporary construction events. The County of Monterey limits noise to 85 dBA with a distance of 50 feet from any sensitive receptors. Combined average noise levels of construction equipment would be about 89 dBA at 50 feet from the operating equipment. There are no residences, schools or other sensitive human receptors in the vicinity of the areas where construction equipment would be working. There is a potential that if sediment fill operations occurred near breeding birds such as near the rookery, that equipment noise could disturb nesting activities. Impacts to breeding birds could be mitigated to less than significant by conducting operations near breeding sites during the non-breeding season or by reducing the noise levels of equipment.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
b) Would the project result in exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☑	☐

Excessive groundborne vibration is typically caused by activities such as blasting used in mining operations, or the use of pile drivers during construction. The project would not require any blasting activities or pile driving. Impacts would be less than significant.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
c) Would the project result in a substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☑

Any potential noise impacts associated with the proposed project would be temporary noise from construction equipment. With the exception of construction events, there would be no increase in ambient noise levels as a result of the project.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
d) Would the project result in a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☑	☐	☐

The proposed project involves the conversion of mudflat and subtidal habitat to salt marsh by fill and potentially the construction of an underwater sill at the UPRR bridge. The generation of noise associated with the proposed project would occur over the short-term for these construction activities. These activities would result in temporary noise levels that would be higher than the existing ambient noise levels in the project area, but would no longer occur once construction is complete. Because there are no schools, residences or other sensitive receptors in the project area, impacts on human receptors would be less than significant. However, as discussed under a0 above, there is a potential that if sediment fill operations occurred near breeding birds such as near the rookery, that equipment noise could disturb nesting activities. Impacts to breeding birds could be mitigated to less than significant by conducting operations near breeding sites during the non-breeding season or by reducing the noise levels of equipment.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☑

There are no airports or private airstrips located near the project.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☑

The project is not located within the vicinity of a private airstrip

XII. POPULATION AND HOUSING

a) Would the project induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project is wetland restoration. The proposed project would not directly or indirectly induce population growth. The project would not induce new employment and no new housing would be constructed.

b) Would the project displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project is wetland restoration. No displacement of existing housing units would result from implementation of the proposed project

c) Would the project displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project is wetland restoration. No people would be displaced as a result of the project.

XIII. PUBLIC SERVICES

		Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
a)	Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services: Fire Protection? Police Protection? Schools? Parks? Other public facilities?	☐	☐	☐	☑

The proposed project is wetlands restoration. The proposed project would not create a new fire or public safety hazard. New employment would not be generated that would affect the demand for schools, parks, or other public facilities. The project would not result in the need for new or physically altered government facilities nor affect response time or other performance objectives.

XIV. RECREATION

		Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
a)	Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☑	☐

The proposed project is wetlands restoration. The proposed project does not involve residential uses and would not cause a direct or indirect increase in the population of the project area. There would be a temporary less than significant impact to Reserve visitors during construction, as construction activities might temporarily degrade the recreational experience and areas might temporarily be closed to the public.

b) Does the project include recreational facilities or require the construction or expansion or recreational facilities which might have an adverse physical effect on the environment?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project would fill subtidal channel and mudflat habitats to increase salt marsh habitat. Recreational facilities will not be expanded or constructed as part of this project.

c) Does the project include potential safety impacts to recreational users?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

There is a potential that construction activities could pose a hazard to Reserve visitors. Safety hazards could be mitigated to insignificant by signs, fencing and safety officers to keep Reserve visitors away from construction areas.

XV. TRANSPORTATION/TRAFFIC

a) Would the project cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☑	☐	☐

The proposed project is wetlands restoration. No permanent increase in traffic would result. Construction activities may involve a temporary increase in traffic on the local roads. If sediment were delivered by truck, trucks delivering loads of sediment could interfere with regular traffic in the project area. Large trucks may create a safety hazard by restricting visibility of cars behind them. In addition, cars may try to pass slow-moving trucks. The impacts of truck traffic could be reduced to less than significant by restricting construction traffic to non-peak hours and limiting the number of trucks on the road at one time.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
b) Would the project exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?	☐	☑	☐	☐

The proposed project is wetlands restoration, and no permanent increase in traffic would occur. During construction a relatively small number of trucks and worker vehicles may increase traffic on local roads. However, these vehicles would not cause a level of service standard to be exceeded. As described above in a), limiting traffic to non-peak use hours would reduce conflicts on local roads and reduce traffic impacts to less than significant.

	Potentially Significant Impact	Less than Significant With Mitigation Incorporation	Less than Significant Impact	No Impact
c) Would the project result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☐	☑

The proposed project would not affect air traffic patterns.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
d) Would the project substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☑	☐	☐

The proposed project does not include the construction of roads and no permanent change in traffic or road use would occur. As described in a), trucks delivering sediment during construction could temporarily interfere with traffic on local roads. Limiting truck traffic to non-peak hours and limiting the number of trucks on the road at one time would reduce truck impacts to less than significant.

e) Would the project result in inadequate emergency access?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

There would be no changes to emergency access from that of present conditions. The construction activity would be required to not block local streets such that emergency access remains open. There would be a less than significant impact.

f) Would the project result in inadequate parking capacity?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

The proposed project is wetlands restoration. The project would have no permanent effect on parking. It is possible that during construction, some of the parking at the Reserve may be used by construction vehicles. A temporary decrease in available parking at the Reserve would be a less than significant impact.

g) Would the project conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☐	☑

The proposed project is wetlands restoration. The project would not conflict with any policies regarding alternative transportation.

XVI. UTILITIES AND SERVICE SYSTEMS

Question	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
a) Would the project exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☐	☑

The proposed project would not require wastewater service. No impacts would occur.

Question	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
b) Would the project require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☑

The proposed project would not require construction of new or expansion of existing water or wastewater services. No impacts would occur.

Question	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
c) Would the project require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☑

The proposed project would not require the construction of new stormwater drainage facilities or the expansion of existing facilities.

		Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
d)	Would the project have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☑

The project would not require a water supply from existing entitlements or resources. Therefore, no impacts would occur.

		Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
e)	Would the project result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☑

The project would not require wastewater service. The local wastewater treatment provider would not be affected.

		Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
f)	Would the project be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☐	☑

The proposed project would not require the use of any landfill. No impacts would occur.

g) Would the project comply with federal, state, and local statutes and regulations related to solid waste?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

The proposed project is wetlands restoration. It would not generate significant amounts of solid waste. If any solid waste is generated all regulations would be complied with.

XVII. MANDATORY FINDINGS OF SIGNIFICANCE

a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

The proposed project is designed to restore balance and wetland functions to the ecosystem of the Parson's Complex. By converting subtidal channels and mudflat to salt marsh, the habitat for some species will be reduced. However, because subtidal and mudflat habitat has been increasing in Elkhorn Slough at the expense of salt marsh, the reduction in habitat for fish and wildlife that use these habitats would not be substantial. The proposed project would not cause a fish or wildlife population to drop below self-sustaining levels. The project would not threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of California history or prehistory.

b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

The proposed project would help to offset the cumulative loss of salt marsh habitat in the greater Elkhorn Slough area. The project would not have any cumulative adverse impacts.

c) Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
	☐	☐	☑	☐

The proposed project would not have any substantial adverse effects on human beings. Adverse impacts to human beings are temporary impacts during project construction. All potential impacts to human beings can be mitigated to less than significant.

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APPENDIX 4-D – ADDITIONAL MODELING OF THE SILL

Note: This analysis was originally provided as a technical memorandum to evaluate the option of using a structure at the mouth of Parsons Slough to moderately restrict tidal exchange and reduce peak channel velocity in the main channel of Elkhorn Slough.

MOFFATT & NICHOL

104 West 40th Street – 14th Floor

New York, NY 10018

Phone (212) 768-7454 ❖ Fax (212) 768-7936

MEMORANDUM

To:	**Chris Webb, Weixa Jin**
From:	**Tucker Mahoney**
Date:	**March 9, 2009**
Subject:	**Numerical Modeling Results**
M&N Job No.:	**6266 Parsons Slough**

The following memorandum is presented as an addendum to the previous memorandum submitted: '6266 Parsons Modeling Results 7-22-08.doc'. All background material and prior results are included in this memorandum.

The model being used for these presented tests to modify water levels in Parsons Slough and test the impact on velocities in Parsons Slough and the main chancel of Elkhorn Slough was developed by Phillip Williams & Assoc. (PWA). It has been calibrated and verified by PWA and has been used in previous studies. For the purposes of this study, the December 2005 verification period was used as it contains a full spring-neap cycle and it is the longest period available for simulation. The PWA model setup was not modified other than to incorporate the proposed alternatives.

Additional Simulations – Winter 2009

The client wished to model the impact of narrowing the entrance to Parsons Slough to widths of 25 ft and 50 ft and installing a weir at the entrance at a height of -2 ft or -5 ft. Due to limitations in model resolution, this could not be modeled explicitly and funds were not available to modify the model.

The client accepted that a box culvert could be used as a proxy for the weir scenario described above because the culvert could be implemented in the existing model without a major modification to the existing model geometry. The following two scenarios have been simulated and results are presented in this addendum:

1. One inflow/outflow culvert with a bottom elevation of -5 ft NAVD88 and a width of 25 ft.
2. One inflow/outflow culvert with a bottom elevation of -2 ft NAVD88 and a width of 50 ft.

Each culvert was chosen to have a height of 15 ft so that it would never be full and a length of 1 ft, to more closely approximate a weir. Flow is allowed both into and out of the culvert, depending upon tidal stage in Elkhorn Slough vs. Parsons Slough.

For both of these simulations, the following information is presented:

- Velocity and water levels at Lower Parsons, South Marsh, Outside, Main Channel 1, Main Channel 2, Main Channel 3 as well as two additional points: Upstream 500 ft in the Main Channel (Upstream 500) and inside the culvert (Culvert). All points are shown in Figureon top of the model bathymetry.
- An estimate of tidal prism is presented for each scenario and compared to existing conditions.

Modeled Water Levels

Water levels at these locations are presented in Figure through Figure for both culvert configurations. Existing conditions are also shown for reference. The first figure for each location (e.g. Figure) presents the modeled water level over the duration of the simulation, while the second figure for each location (e.g. Figure) presents a shorter snapshot of water levels from February 13, 2005 through February 17, 2005). This second period encompasses a spring tide peak.

Modeled Velocity

Modeled velocity results at each location are given in the attached Excel file: 'Mach 2009 Addl Simulations - Velocity.xls'. The velocity is specified by its east and north components in ft/s.

Estimated Residence Time for Culvert Configuration 1

In this addendum, the residence time is estimated in the same manner as presented in '6266 Parsons Modeling Results 7-22-08.doc'. Please reference this memorandum for background and methodology.

Under Culvert Configuration 1, the volume exchanged through the culverts over this typical tidal cycle is 2,498,000 cy. Comparing this to the volume of Parsons Slough (approx. 2,783,000 cy) and the modeled existing conditions, it can be determined that the residence time has increased to be 1.4 times that of existing conditions, or approximately 2.2 tidal cycles.

Estimated Residence Time for Culvert Configuration 2

Under Culvert Configuration 2, the volume exchanged through the culverts over this typical tidal cycle is 3,232,000 cy. Comparing this to the volume of Parsons Slough and the modeled existing conditions, it can be determined that the residence time has increased to be 1.1 times that of existing conditions, or approximately 1.7 tidal cycles.

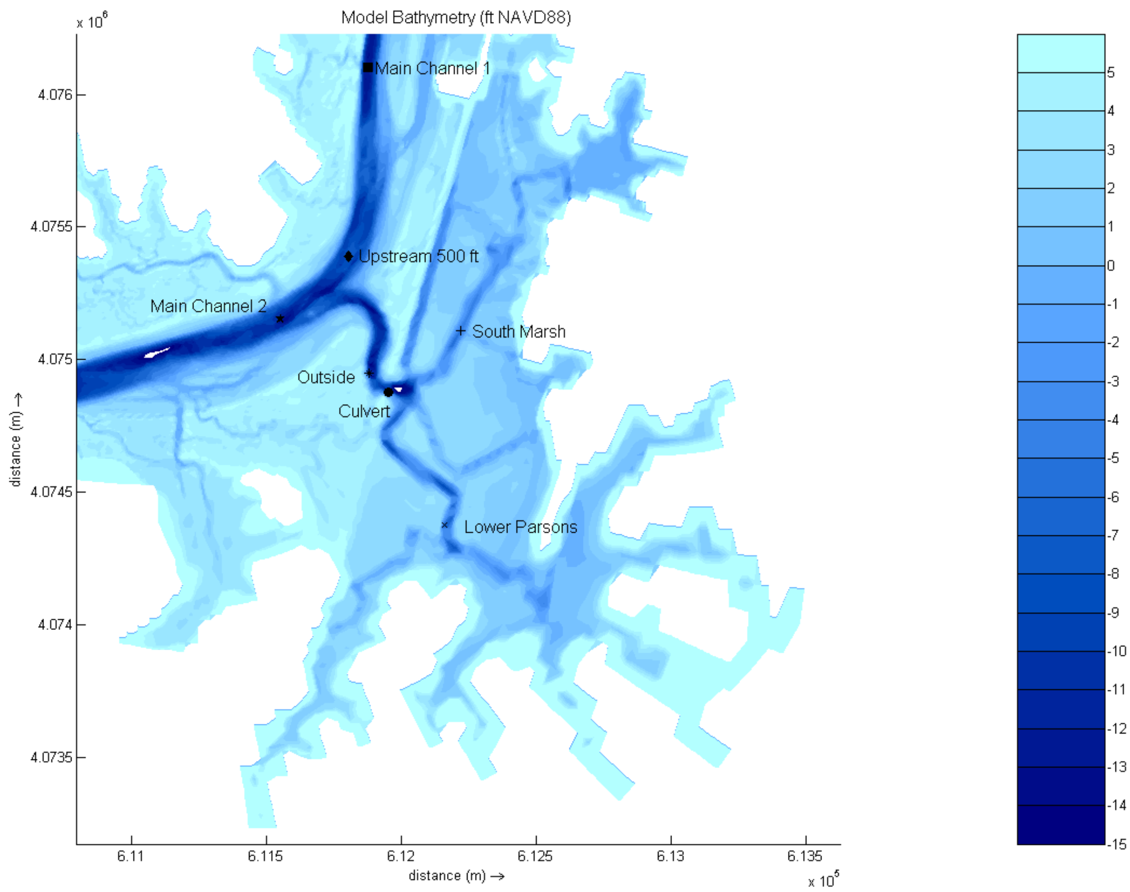

Figure 4-D-1. Location of Water Level and Velocity Points (over Model Bathymetry – ft NAVD88)

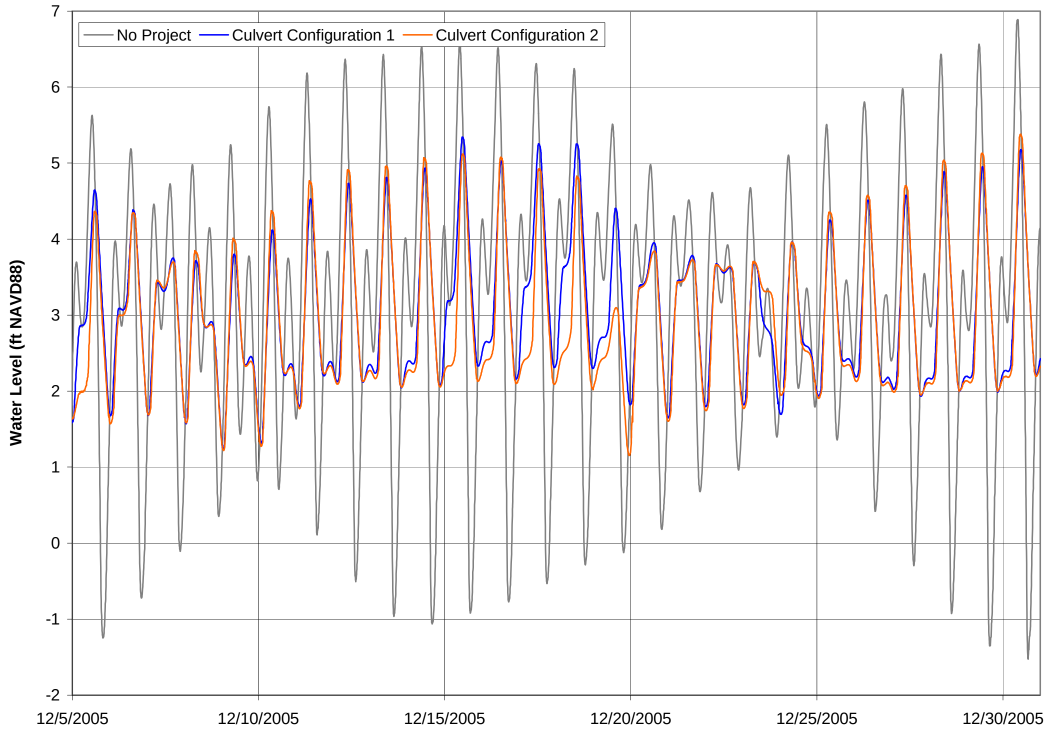

Figure 4-D-2. Water Level in Lower Parsons

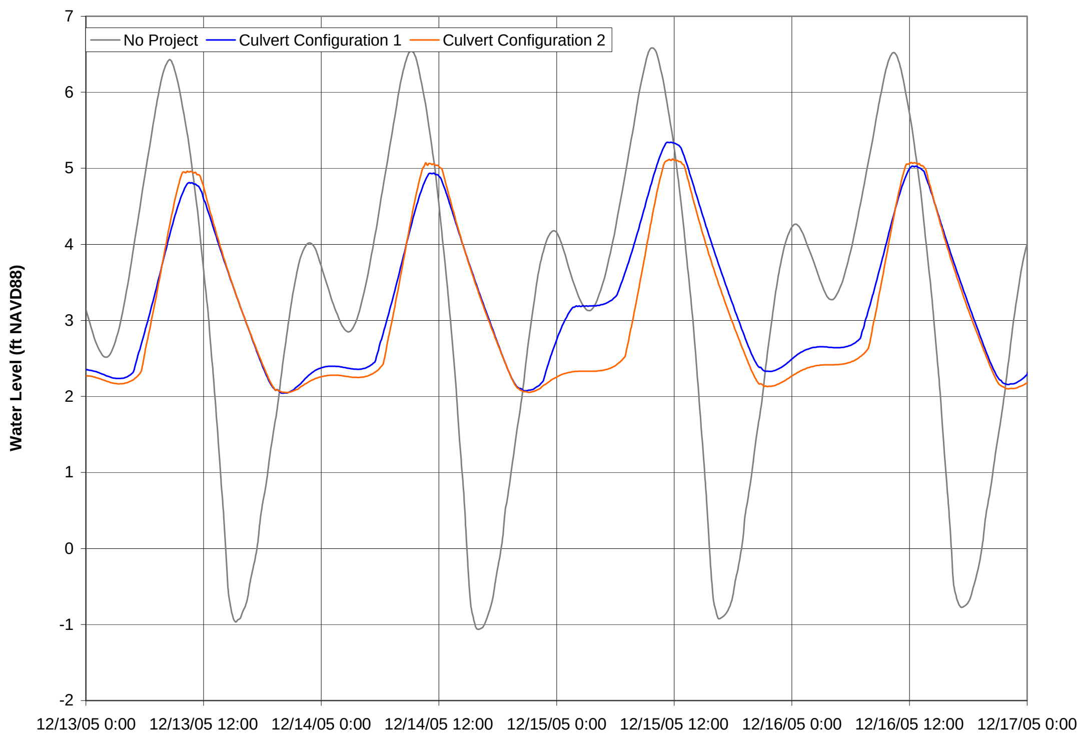

Figure 4-D-3. Water Level in Lower Parsons

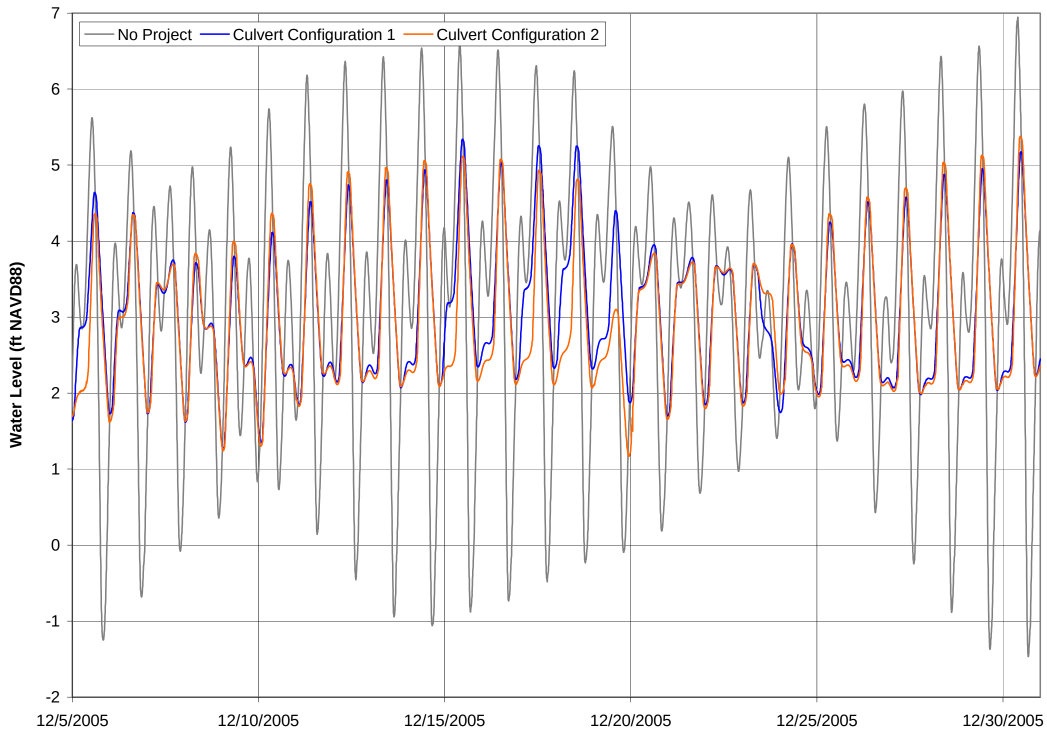

Figure 4-D-4. Water Level in South Marsh

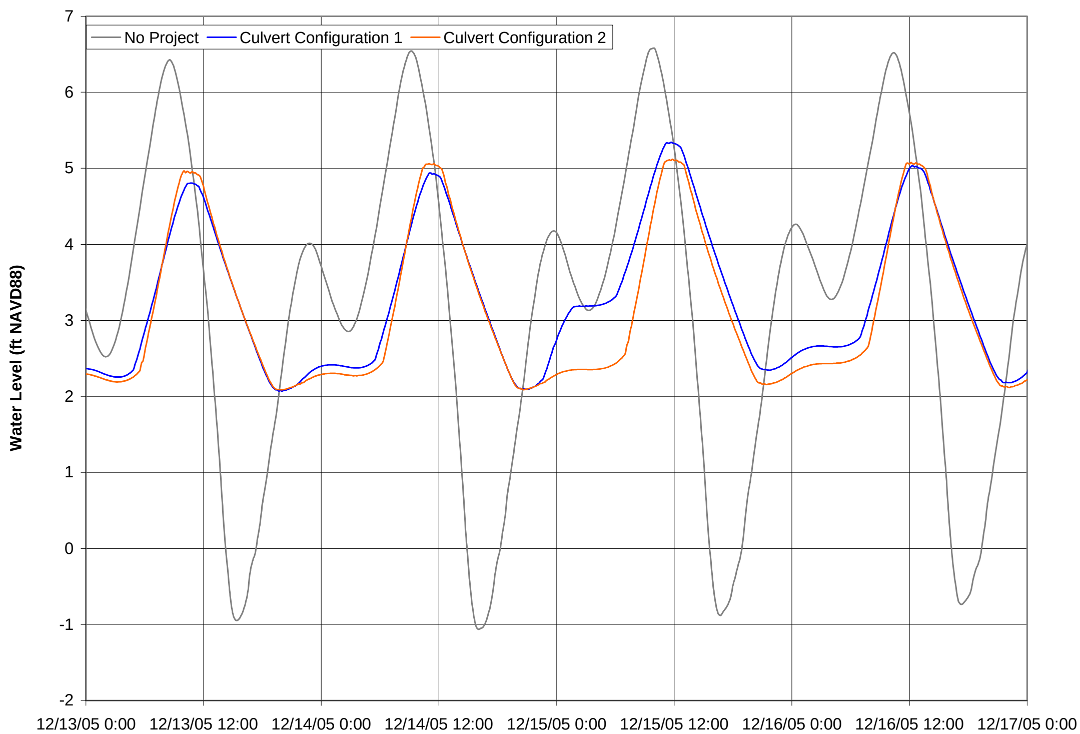

Figure 4-D-5. Water Level in South Marsh

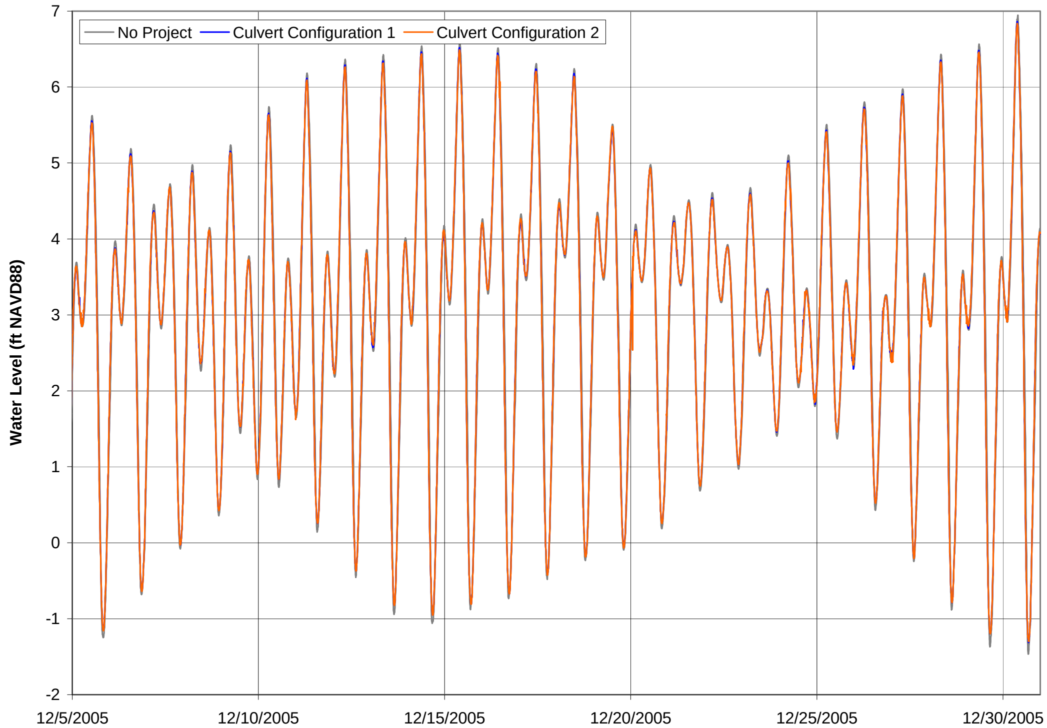

Figure 4-D-6. Water Level Outside of Culvert

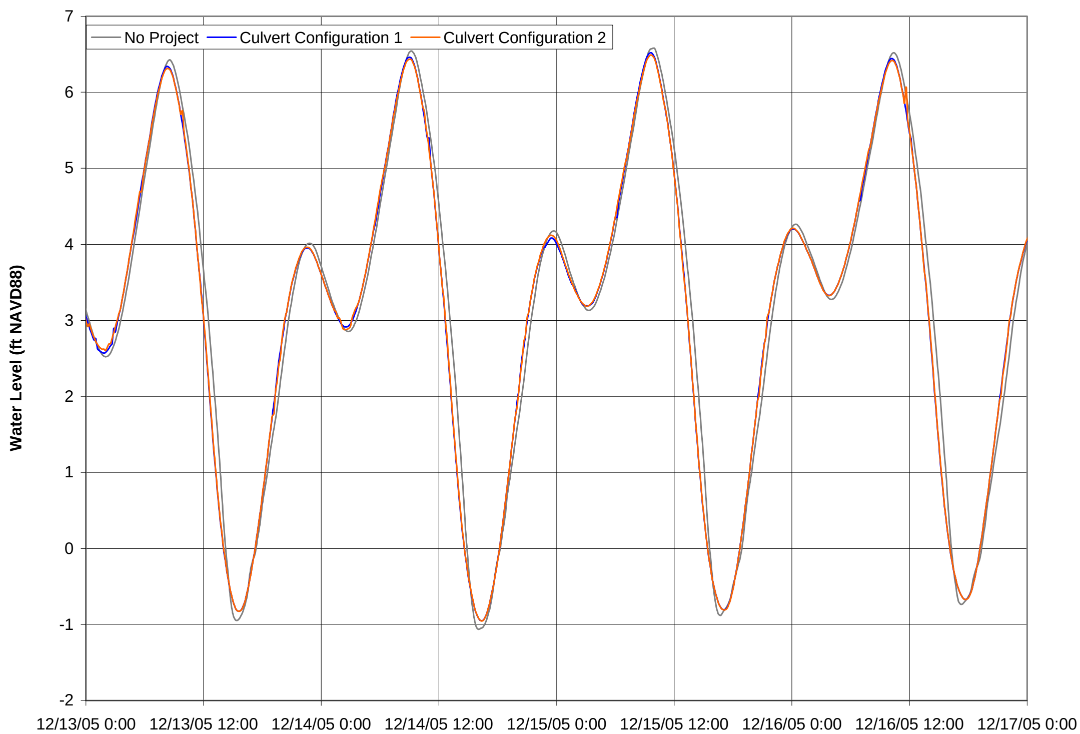

Figure 4-D-7. Water Level Outside of Culvert

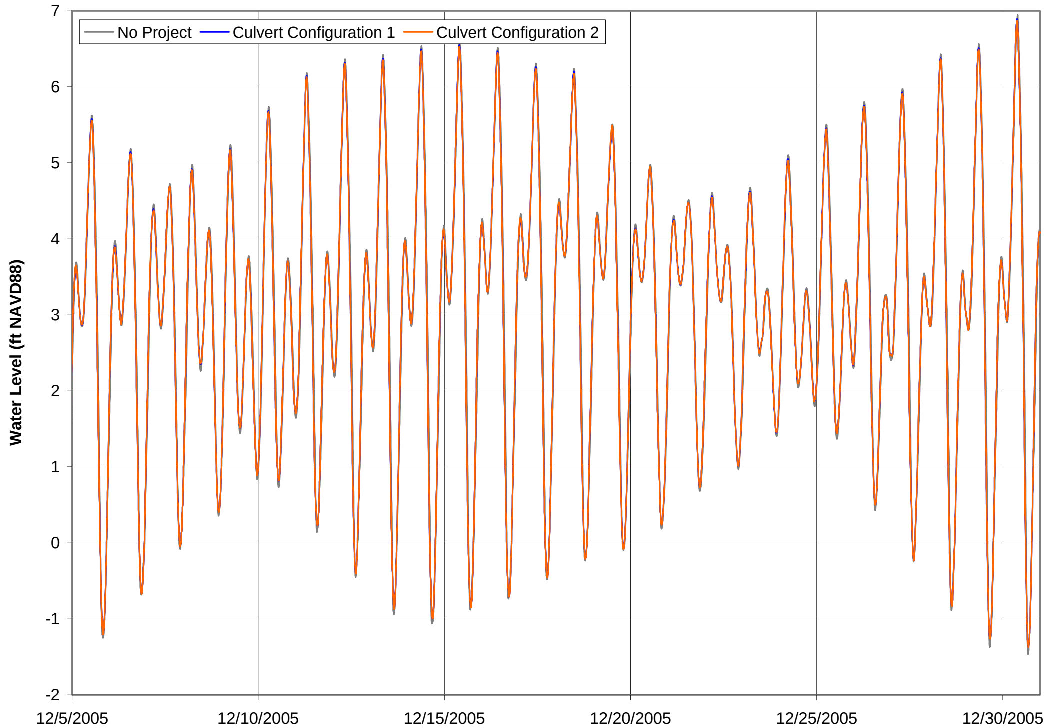

Figure 4-D-8. Water Level at Main Channel 1

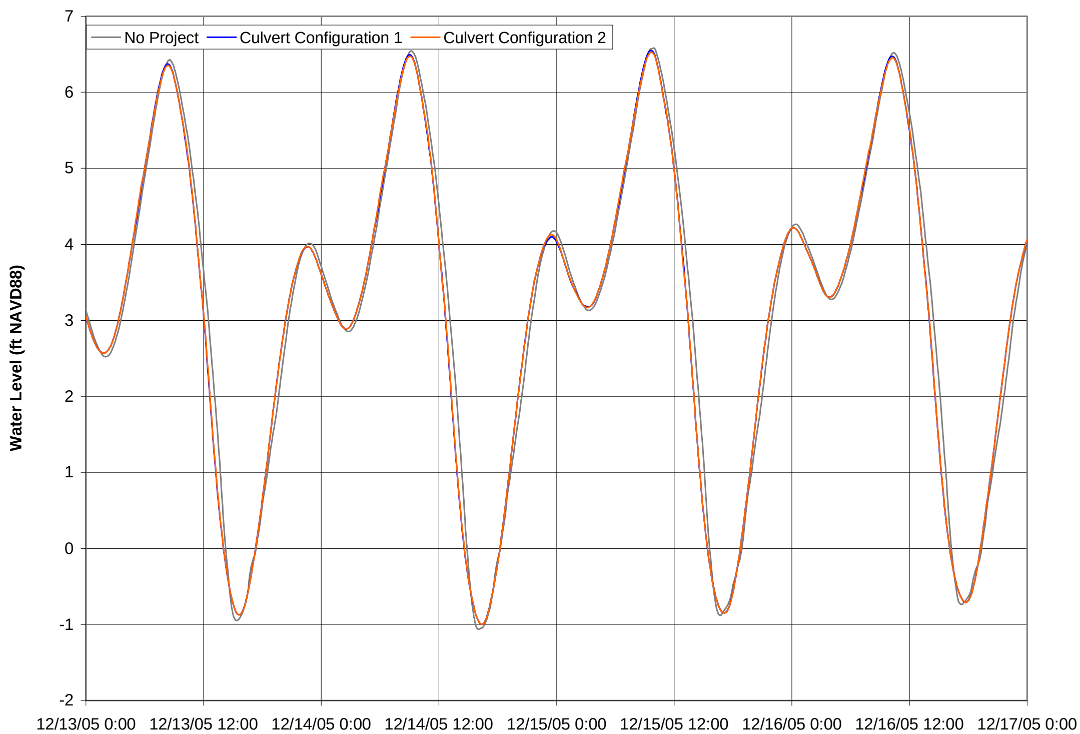

Figure 4-D-9. Water Level at Main Channel 1

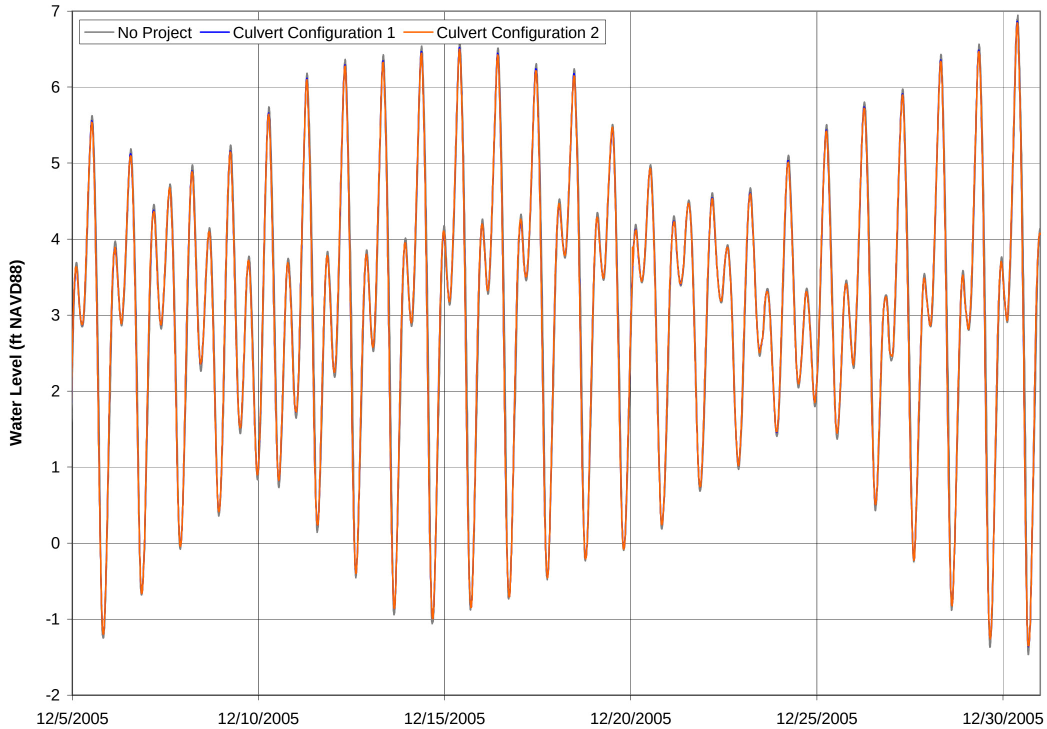

Figure4-D-10. Water Level at Main Channel 2

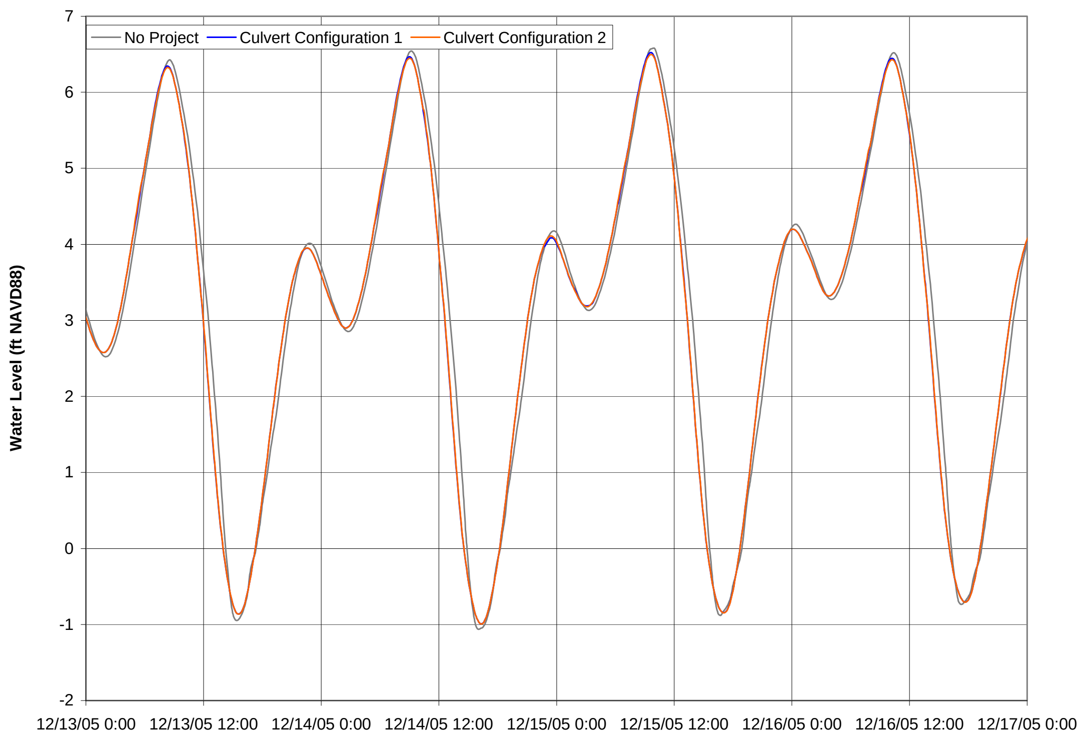

Figure 4-D-11. Water Level at Main Channel 2

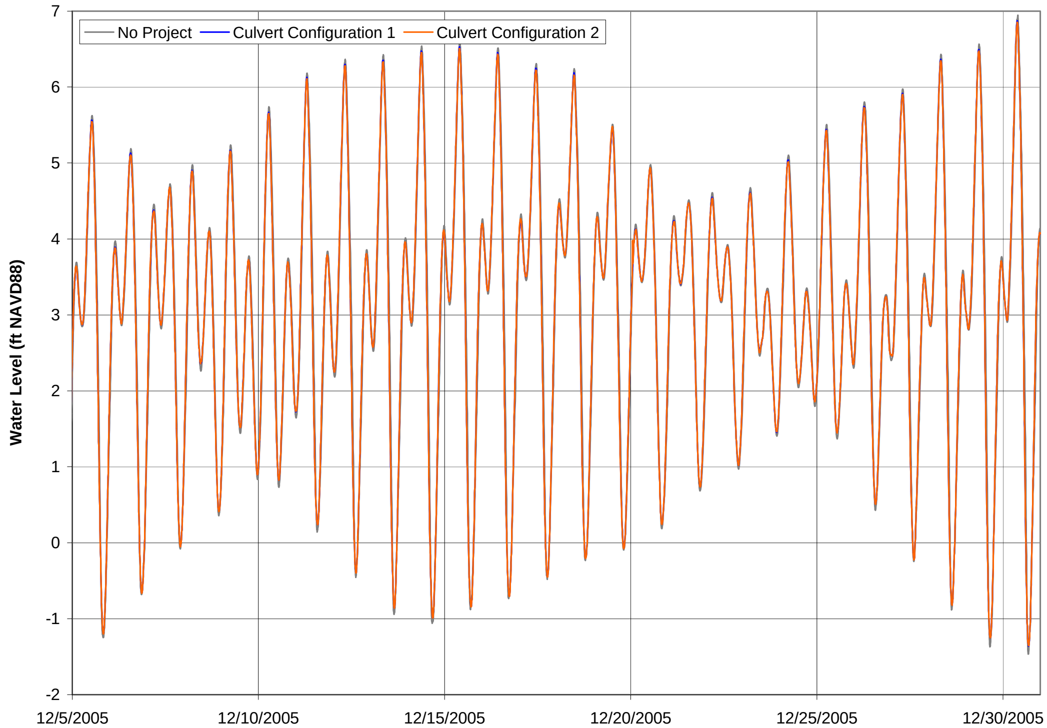

Figure 4-D-12. Water Level at Main Channel – Upstream 500ft

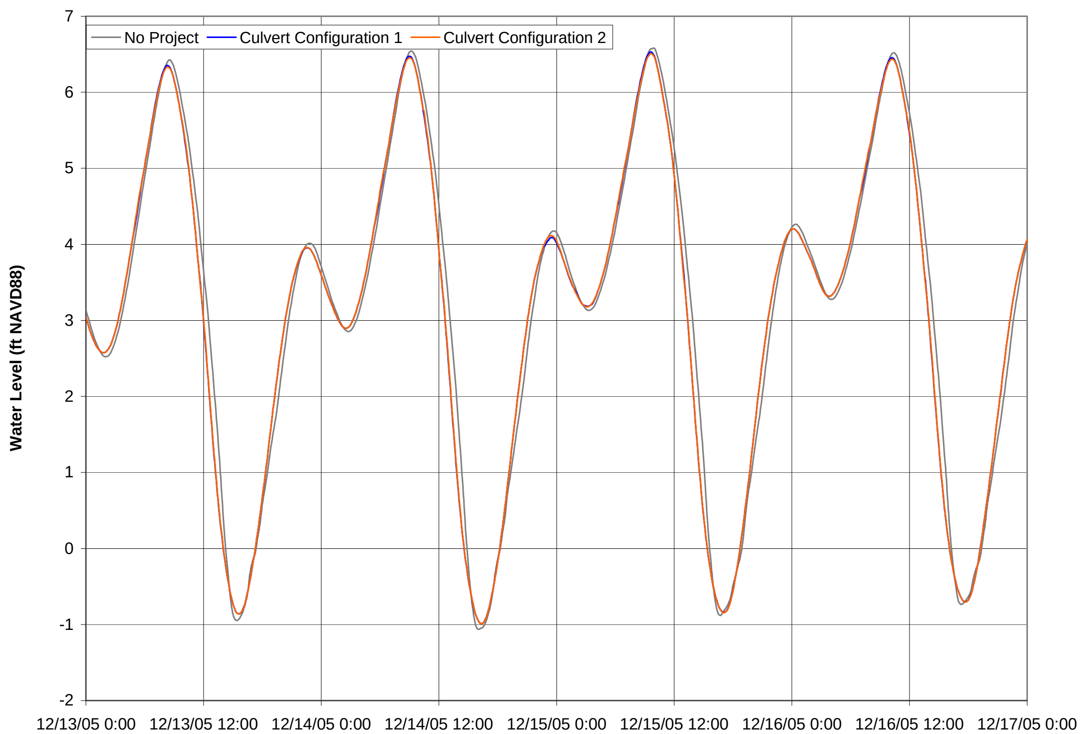

Figure 4-D-13. Water Level at Main Channel – Upstream 500ft

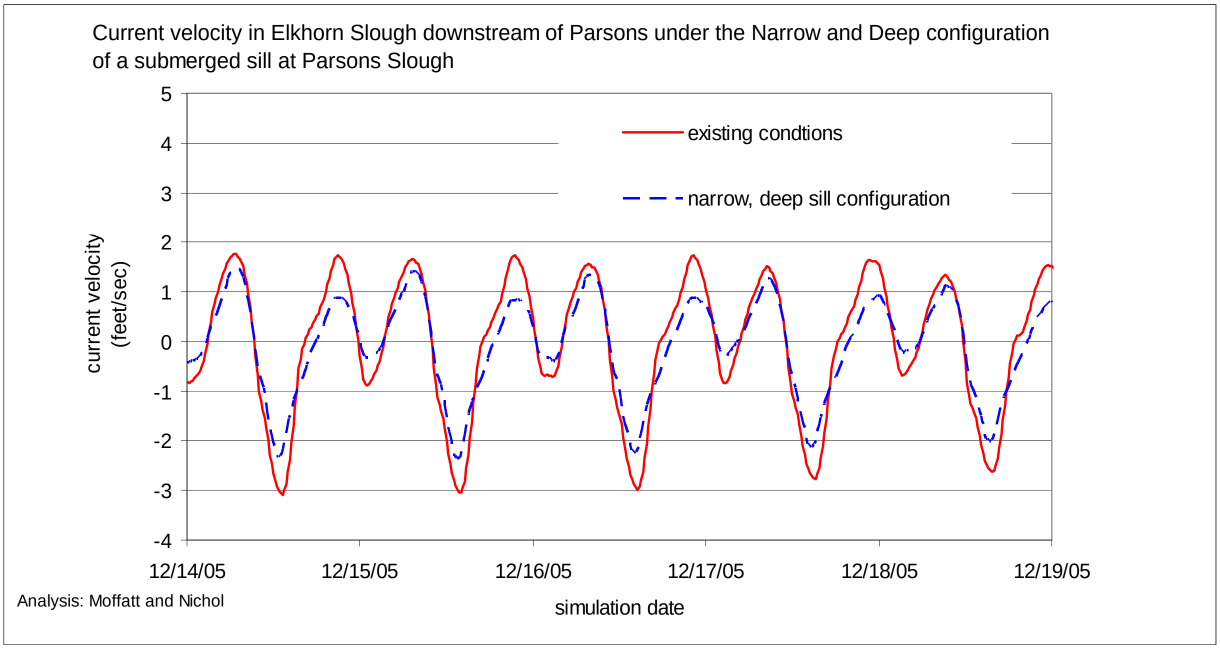

Figure 4-D-14. Velocity reduction in Elkhorn Slough resulting from a restrictive sill at the mouth of Parsons Slough

MOFFATT & NICHOL

3780 Kilroy Airport Way, Suite 600, Long Beach, California 90806
phone: 562-426-9551 fax: 562-424-7489