BOLINAS LAGOON ECOSYSTEM RESTORATION PROJECT


U.S. Army Corps of Engineers


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RECOMMENDATIONS FOR RESTORATION AND MANAGEMENT

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National Marine Sanctuaries

Marin County Open Space District, Department of Parks & Open Space

US Army Corps of Engineers

National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Gulf of the Farallones National Marine Sanctuary Advisory Council

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Bolinas Lagoon Ecosystem Restoration Project

Recommendations for Restoration and Management

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Executive Summary

This document provides a suite of recommendations that address human activities that result in outputs that directly and indirectly impact Bolinas Lagoon (lagoon). The ecological and physical functions of Bolinas Lagoon are influenced by ongoing interactions among sea level dynamics, earthquakes and sedimentation. Since the early 19th century, human land uses have altered the shoreline and watershed, changing the proportion of human-caused sediment reaching the lagoon, threatening water quality and altering the rate at which natural processes shape the lagoon. The result is a human-induced acceleration and alteration in the natural processes, resulting in a loss of tidal prism and changes in composition of plants, animals and habitats.

A Working Group of the Gulf of the Farallones National Marine Sanctuary (GFNMS) Advisory Council developed this document, in partnership with Marin County Open Space District (MCOSD), the United States Army Corps of Engineers (the Corps), and the public. The Working Group, composed of scientists, local stakeholders, environmental groups, and state and federal agency representatives forwarded their recommendations to the full GFNMS Advisory Council. The Advisory Council reviewed, discussed and forwarded the recommendations to the GFNMS Superintendent, who has forwarded the document onto MCOSD and the Corps.

The thirteen recommendations contained in this document constitute the Locally Preferred Plan *(Section 2 – Restoration recommendations in the Locally Preferred Plan)*. The Corps will analyze and consider these recommendations and include them (among other alternatives) in the Bolinas Lagoon Ecosystem Restoration Feasibility Study. Additionally, this document identifies recommendations for long-term management actions that may be implemented independently of the Bolinas Lagoon Feasibility Study, which are described in *Section 3 – Management Recommendations for Bolinas Lagoon*. Finally, recommendations for adaptive management and monitoring are described in *Section 4 – Framework for an Adaptive Management and Monitoring Program*.

The recommendations presented in this document are based on the following vision statement, project goal and objectives. These guiding principles were used in the development of this document.

Vision Statement: Bolinas Lagoon thrives naturally as an ecologically healthy tidal estuary.

Project Goal: The Bolinas Lagoon Ecosystem Restoration Project aims to ameliorate adverse human impacts to the lagoon, thereby promoting the natural, dynamic, geologically evolutionary processes of this internationally-recognized estuarine environment.

Objectives:
1) Restore natural sediment transport and ecological functions of Bolinas Lagoon by ameliorating the negative effects of human induced changes.
2) Identify and manage introduced species in the Bolinas Lagoon watershed.
3) Protect water quality by minimizing negative human impacts.

This document focuses on addressing human impacts to the lagoon and restoring — as much as possible — its natural hydrological and ecological functions. Each recommendation aims to provide long-term solutions, rather than short-term fixes. The Working Group recognizes that the lagoon is constantly changing and that the timing and affect of future natural small and large scale events (e.g., sea level rise, frequency and intensity of major storms, earthquake magnitude and timing) are uncertain and that the best way to ensure the long-term health of the lagoon is to restore the processes that allow it to evolve naturally.

A key element of the Locally Preferred Plan *(Section 2)* is floodplain restoration. The restoration and reconnection of habitat along the lagoon's edge and upland habitat will allow for connectivity between these ecologically valuable areas and allow the lagoon to move inland in response to sea level rise. Other key recommendations for restoration actions include:

- Remediate watershed disturbances;
- Remove areas of unnatural levels of sedimentation (deltas) from the lagoon;
- Restore Kent Island as a dynamic flood shoal island;
- Restore eelgrass, if suitable habitat is available in Bolinas Lagoon;
- Investigate managing tidal exchange of Seadrift Lagoon to promote tidal circulation; and
- Actively plan and manage for sea level rise.

Elements of *Section 3 – Management Recommendations for Bolinas Lagoon* include the following suite of actions: implementing best management practices, removing fallen trees from the

lagoon, establishing a responsible wildlife viewing program, and developing an emergency response plan in the event of an inlet closure. Other recommendations focus on managing introduced species throughout the Bolinas Lagoon watershed, such as a rapid response plan for immediate removal of introduced cordgrass and a plan for identification and removal of other invasive species. Management recommendations to protect the lagoon's water quality include: developing a local oil spill response plan, replacing toxic-impregnated materials, promoting environmentally sensitive use of restroom facilities, and identifying toxins associated with the abandoned dredge. Combined, these management recommendations will conserve the rich ecological diversity of Bolinas Lagoon and its watershed.

Section 4 – Framework for an Adaptive Management and Monitoring Program describes techniques for reviewing and adjusting management practices based on information gained through monitoring. Managing for a healthy Bolinas Lagoon is dependent on the ability to learn and then adapt management practices. Adaptive management is an iterative process which allows resource managers (MCOSD and GFNMS) the ability to implement conservation strategies, monitor the outcomes, and then adjust practices, if needed.

The recommendations in this document are from NOAA, through the GFNMS Working Group and the Sanctuary Advisory Council, to the MCOSD and the Corps. This document was developed through a community-based process, by which public comments were accepted at scheduled times during all eight Working Group meetings. Comments received at the public workshop (June 11, 2008) and during the 30-day public comment period were compiled and presented to the Working Group. The Working Group convened for a final meeting to consider public comments and finalize the document. *Section 5 – Conclusions*, provides a detailed discussion on the current process and public involvement, future implementation strategies, and overarching challenges.

This document is the precursor to the preparation of an environmental impact statement (EIS) under the National Environmental Policy Act (NEPA) and an environmental impact report (EIR) under the California Environmental Quality Act (CEQA). The environmental review will be based on the proposed actions in this document (i.e., the Locally Preferred Plan). NOAA's Office of National Marine Sanctuaries will request to be a cooperating agency with the Corps on the EIS/EIR to ensure the resources and qualities of the Gulf of the Farallones National Marine Sanctuary are properly addressed throughout the process.

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Section 1. Introduction

1.1 Bolinas Lagoon: A Wetland of International Importance

Bolinas Lagoon's 1,100 acres was designated a Wetland of International Importance by the Ramsar Convention[1] in 1998. This tidal estuary lies on the San Andreas Fault, 15 miles northwest of San Francisco (Figure 1). The channels, mudflats, marsh and riparian areas provide rich habitat for a myriad of shorebirds and waterfowl, fish and invertebrates, and special status plants and animals. Located on the Pacific Flyway, Bolinas Lagoon is an important wintering area for many thousands of bird species. The lagoon also plays an important role for resident breeding colonies of herons and egrets. The protected sand bars and islands provide pupping grounds and year-round haul-out sites for harbor seals. Subtidal areas and extensive mudflats support diverse populations of invertebrates and provide nursery and feeding habitat for resident and migratory fish. Steelhead and coho salmon move through the lagoon to access streams in the 16.7 square mile watershed. The lagoon is an important part of a network of northern California estuaries, some of which are relatively pristine and others that are being restored. Together these estuaries provide a wetland complex of exceedingly rich ecological value.

1.2 Natural Processes and Constant Change

Bolinas Lagoon is a complex ecosystem that has been in a state of constant change ever since its formation roughly 8,000 years ago. Since forming, the lagoon has moved inland, responding to sea level rise. The PWA Report (2006[2]) indicates that the greatest forces that have affected the lagoon include large-scale earthquakes which deepen the lagoon, wind, wave and tidal energy that transport littoral

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[1] The Ramsar Convention and the United States Army Corps of Engineers define "wetlands" differently. For the purpose of this document we will use "wetlands" as defined by the United States Army Corps of Engineers. See glossary for definitions.

[2] This reference is to Section II – "Projecting the Future of Bolinas Lagoon," by Philip Williams & Associates, Ltd. and Wetland Research Associates. Section II is one of six sections within a two volume document compiled by several authors. The full report can be found at http://www.co.marin.ca.us/pos/MCOSD/Bolinas-Lagoon-Updates.asp.

sediments in and out of the lagoon, severe winter storms that transport sediments from the watershed into the lagoon, and sea level rise.

Two sediment sources contribute to the natural processes of Bolinas Lagoon: ocean (littoral) and watershed (fluvial) sediment. Approximately 80% of the sediment deposited into the lagoon is ocean derived beach sand that is swept in during flood tides and primarily settles near the inlet and the central part of the lagoon, forming both an interior flood shoal island (Kent Island) and a submerged sand bar on the ocean side of the inlet (PWA Report 2006). Fine-grained silt eroded by waves from the Bolinas Bluffs makes its way through the inlet and into the lagoon. Although a small fraction of silt enters the lagoon, tidal flood currents are able to transport these fine sediments far into the north and south ends of the lagoon. The remaining 20% of deposited sediment comes from the watershed, via creeks and runoff (PWA Report 2006).

Large[3] earthquakes along the San Andreas Fault deepen the lagoon and counteract the natural sediment transport processes. On average, these earthquakes occur every 250 years (Zhang *et al.* 2006). The sudden deepening of Bolinas Lagoon, caused by large earthquakes, is followed by increased transport and deposition of littoral sediment into the lagoon. Gradually, as more littoral sediment replaces sediment compacted by seismic processes, deposition slows. The accumulated sediment results in a reduced tidal prism. Consequently, these shifts in tidal prism lead to a natural succession of associated plant and animal communities as sediment elevations change.

Tidal currents drive the net transport pattern of littoral sediment into the lagoon. Waves caused by winds across the lagoon erode and re-suspend sediment from tidal mudflats. Once suspended in the water column, the sediment is distributed throughout the lagoon or transported out the inlet by ebb tides (PWA Report 2006).

1.3 Need for Action

The ecological and physical functions of Bolinas Lagoon are influenced by ongoing interactions among sea level dynamics, earthquakes and sedimentation. Since the early 19th century, human land uses have altered the shoreline and watershed, changing the proportion of human-caused sediment

[3] A large earthquake as defined by the United States Geological Survey has a magnitude ≥ 6.7.

reaching the lagoon, threatening water quality and altering the rate at which natural processes shape the lagoon. The result is a human-induced acceleration and alteration in the natural processes, resulting in a loss of tidal prism, and changes in composition of plants, animals and habitats.

Human Impacts to Bolinas Lagoon

Human land use activities result in outputs that directly or indirectly affect the lagoon. Many historical anthropogenic activities have caused increased sediment delivery and deposition, which, in turn, have affected some of the physical processes that drive the natural evolution of the lagoon. For example, the results of adding fill for Seadrift housing, Highway 1, and Wharf Road directly impact the lagoon, increasing sediment availability and altering the physical processes. The consequences of hardening the shoreline along Highway 1, Dipsea and Wharf Roads have also directly impacted Bolinas Lagoon by preventing connectivity between the lagoon and upland habitats. Finally, construction in the floodplains, and the rerouting and channelization of creeks has resulted in impaired floodplain functions, in some instances increasing the amount of sediment deposited in the lagoon and reducing the tidal prism.

Indirect human land uses that have increased sediment entering into the lagoon include: historic logging and farming activities, grazing, wood cutting, conversion of perennial to annual grasslands, and channelization of Pine Gulch Creek (PGC). Combined, these anthropogenic activities have altered the natural evolution of the lagoon.

Figure 2 identifies how human changes, primarily to the watershed and the perimeter of the lagoon, have affected physical functions (i.e., sediment transport) which have resulted in conversion of wetland habitats and loss of tidal prism. The left side of Figure 2 is the focus of the Locally Preferred Plan — human caused changes — that if ameliorated would result in restoring some of the natural sediment transport and ecological functions to Bolinas Lagoon.

The effects of human-caused activities can be shown by comparing the 1854 T-Sheets or topographic maps to the present-day condition of Bolinas Lagoon. The 1854 T-Sheets were developed only five years after extensive timber harvesting in the watershed began. The T-Sheets depict Bolinas Lagoon as a primarily shallow mudflat with relatively little salt marsh or subtidal shallows (PWA Report 2006). Well developed tidal channels in the north basin suggest that the lagoon had been shallow for an extensive period of time.

The floodplains of the creeks are functionally connected to the lagoon without the use of culverts in the 1854 T-Sheets. Furthermore, the lagoon perimeter is not hardened, showing connectivity between estuarine and marsh habitats and adjacent uplands. Compared to today, the 1854 T-Sheets show a smaller Kent Island and a larger Bolinas Channel. The 1854 T-Sheets show no delta extending beyond the mouth of PGC and no houses or interior artificial lagoon on the sand spit, now occupied by the Seadrift development.

The most recent major earthquake prior to 1854 occurred approximately 335 years earlier in 1519. One can then assume that the 1854 T-Sheets represent the natural condition of the lagoon — before significant human-induced disturbances and long after a major earthquake. These 1854 references are a snapshot in time, which is our best depiction of the lagoon in a relatively pristine state.

The PWA Report (2006) states 80% of the sediment entering Bolinas Lagoon is littoral sediment from natural processes; however, human land use changes in the watershed and creek channelization have increased sediment accumulation in the north and south basins by at least 2 to 3 times more than late Holocene rates (Byrne *et al.* 2005). The rate of watershed sedimentation is expected to continue at the present level when averaged over several decades. As the strength of tidal currents reduces in response to diminished tidal prism, future rates of net sedimentation will slow.

Much of the lagoon's perimeter has been hardened by bordering roadways, such as Highway 1, Olema-Bolinas Road, Wharf Road, and bulkheads at the Bolinas inlet and along the interior of Seadrift. These hardened shorelines limit the lagoon's ability to expand inland in response to rising sea levels. Many of the recommendations in this document focus on restoring the lagoon's edges (e.g., floodplain recovery and constructing causeway bridges) to allow the lagoon to move inland where possible, and to preserve the ecological integrity of the lagoon while preparing for sea level rise.

The Intergovernmental Panel on Climate Change or IPCC (2007) concluded sea level will probably rise 18 to 59 cm (7.08 - 23.22 inches) during the 21st century. However, the climate models used to make these predictions accounted for only two of the three factors that significantly contribute to sea level rise: 1) thermal expansion of ocean water and 2) melting glaciers. The third contributor to sea level change which was lacking in the IPCC (2007) estimation is ice sheet disintegration. Ice streams are a result of surface melt descending through crevasses and lubricating basal flow beneath ice sheets (Hansen 2007). Evidence of increasing ice sheet melt has doubled in the past decade and is now close to 1 millimeter per year (Hansen 2007). If ice sheets continue disintegrating on this trajectory sea level rise will no longer follow a linear projection, but will track a more nonlinear approximation. Hansen (2007)

estimates, if ice sheets disintegrate 1 cm (0.40 inches) over the next decade (2005-2015) sea level will rise 5 meters (16.04 feet) this century.

Sea level will affect the biological and physical processes of the lagoon. As new information evolves, it is critical the most up to date sea level rise estimates are used in future analyses for the Bolinas Lagoon Ecosystem Restoration Feasibility Study.

Ecological Functions

Analyses of the 1854 T-Sheets and estimates from the 50-year projection indicate that humans will have caused a 1.2 million cubic yard reduction in tidal prism and a shift of habitats from subtidal and low intertidal mudflat to higher intertidal mudflat and tidal marsh. Subtidal shallows will be lost, frequently submerged mudflat will decrease by 26%, frequently exposed mudflat will increase by 24%, tidal marsh will increase by 22%, and fluvial delta (that supports riparian forest) will increase by 82%. Species abundance and diversity in the lagoon will change with these habitat shifts. However, it is difficult to predict how individual populations will respond to these changes.

The high productivity of estuaries is due to the in situ photosynthetic activity of various types of plankton, submerged vascular plants, benthic algae, tidal marsh detritus, and freshwater runoff. Shifts in habitats that support these sources in the lagoon's food web will have cascading ecological effects.

The loss or conversion of wetland habitats — and reduction in tidal prism — affects the ecological functions of the lagoon, but it proves difficult to quantify how these observed habitat shifts have impacted plants, invertebrates, fish and other wildlife. Eelgrass has largely disappeared from the lagoon and populations of large clams have declined. However, long-term data on invertebrates and fish are lacking, making it difficult to assess how shifts in habitat have affected populations of these taxa.

The Pacific Ocean was in a warm period from 1980 to 2000, compared to a cool phase for approximately 40 years prior (Mantua & Hare 2002). These factors affect the biology of the ecosystem and need to be considered when looking at Bolinas Lagoon.

Data (PRBO Conservation Science) indicate population declines in diving waterfowl, but it may be that this decline is due to conditions outside of Bolinas Lagoon. Bolinas Lagoon and much of its fish and wildlife are intimately connected to environmental changes outside the lagoon and it will remain difficult to relate changes in species abundance and diversity directly to changes in habitats and habitat quality within the lagoon. However, species that depend on specific habitats are expected to either

increase or decrease depending on the trends in habitat loss or gain. For example, one-third of the 99 invertebrates listed as occurring in the lagoon are associated with subtidal and frequently submerged mudflat areas and are expected to experience declines as their habitat areas decrease (PWA Report 2006). Similarly, decreases in deeper water habitat will reduce foraging habitat for two feeding guilds of diving birds (fish-eating and benthos-feeders) and most of the 38 species of fish known to occur in the lagoon (PWA Report 2006).

Some shorebirds are expected to lose habitat while others will gain. Marsh bird populations are expected to benefit as are migratory and resident land birds by the increase in marsh and riparian forest habitats. For example, an increase in brackish marsh will benefit the state-threatened California black rail, the salt-marsh common yellowthroat — a state and federal Species of Concern, and the marsh wren (PWA Report 2006).

1.4 Intellectual Framework Implemented by the Working Group

The following describes ten principles used by the Working Group to develop the Locally Preferred Plan and Management Recommendations. The methods or analytical procedures implemented by the Working Group are also described. This framework along with the vision statement, project goal and objectives set the stage for the development of this plan.

Principles

1) The Working Group supports an adaptive management strategy that encourages collaboration between public and private interests to define and solve environmental problems for Bolinas Lagoon.
2) The Working Group recognizes that the public and the regional community of coastal engineers, scientists and natural resource managers are primary identifiers of environmental issues and concerns for Bolinas Lagoon.
3) The Working Group assumes that the conditions of Bolinas Lagoon are mainly governed by the dynamic interplay between water supplies and sediment supplies that originate in either the marine environment or local watersheds. This interplay creates a dynamic physical template for biological and ecological processes. Therefore, the Working Group further assumes that remedies

to environmental issues and concerns will usually depend on alterations of physical processes. Any effort to manage populations of plants and animals in the lagoon will involve changes in physical processes that control the distribution, abundance, and physical condition of their habitats.

4) The Working Group has focused on environmental issues and concerns, where humans have caused the greatest impact along the lagoon shoreline and watershed, especially areas of transition from estuarine tidal processes to fluvial or terrestrial processes in the lower reaches of local watersheds.

5) The Working Group has focused on remedies that are consistent with natural processes, such that the desired effects of the remedial actions tend to be naturally supported and sustained with minimum intervention and cost, while adequately protecting people and private property.

6) The Working Group does not expect to recover previous conditions in Bolinas Lagoon, or to prevent existing conditions from changing naturally.

7) The Working Group recognizes that people have had, and will continue to have, ongoing effects on the condition of Bolinas Lagoon. The intent of the Working Group is to improve the relationship between people and the lagoon, such that its ecological integrity and cultural services can be better protected.

8) The Working Group will remain open to new ideas and will respect and document dissenting views, as it works to develop a consensus of understanding about the environmental issues and concerns it attempts to address.

9) The preeminent objective of the Working Group is to do no harm to Bolinas Lagoon.

10) The Working Group is interested in achieving long-term solutions and must consider how the effects of its recommended actions might vary over a 50-year period.

Analytical Procedures of the Working Group

Following the development of the vision and problem statements, and the project goal and objectives, the Working Group was tasked with identifying the environmental issues and concerns about Bolinas Lagoon, based on recent studies and public commentary. These issues and concerns were

compiled in a matrix of possible conservation actions. Actions were recommended for each issue or concern based on the consensus answers to the following questions.

1) What natural processes govern the environmental conditions that have been identified as an issue or concern?

2) How have people affected the environmental conditions that have been identified as an issue or concern?

3) Can the issue or concern be remedied by management actions that are likely to be sustained by natural processes? If so, then describe and recommend the optimal management actions, and describe and recommend the monitoring effort that is needed to evaluate their effectiveness.

4) Is the issue or concern a consequence of natural processes or the actions of people that cannot be sustainably altered or managed? If no management actions can sustain a remedy, then the Working Group recommends no action be taken. Furthermore, the Working Group recommends developing a description why the management actions are likely to fail, and describe and recommend the monitoring effort that is required to determine if the no-action decision is optimal.

5) Is the existing information about the natural and unnatural causes of the issue or concern insufficient to determine whether or not it can be remedied by a management action? If so, then describe the information that is needed to determine the relative importance of nature and people as causes of the issue or concern, and recommend studies or monitoring efforts that will provide the needed information.

Finally the Working Group revised the recommended actions and supporting rationale based on public review, while adhering to the vision, goal, principles, and analytical procedures developed earlier in the process.

Vision Statement

Bolinas Lagoon thrives naturally as an ecologically healthy tidal estuary.

Project Goal

The Bolinas Lagoon Ecosystem Restoration Project aims to ameliorate adverse human impacts to the lagoon, thereby promoting the natural, dynamic, geologically evolutionary processes of this internationally-recognized estuarine environment.

Objectives

1) Restore natural sediment transport and ecological functions of Bolinas Lagoon by ameliorating the negative effects of human induced changes.
2) Identify and manage introduced species in the Bolinas Lagoon watershed.
3) Protect water quality by minimizing negative human impacts.

1.5 Project Justification

This document takes a proactive approach to protecting and restoring Bolinas Lagoon and its watershed. This plan focuses on addressing human impacts and restoring — as much as possible — natural hydrological and ecological functions. By removing or minimizing human impacts the ecosystem will have an opportunity to evolve naturally.

Each recommendation was developed using the ten principles and analytical procedures previously described. Overall, the recommendations were developed with the philosophy of avoiding repeated measures in order to maintain a static state. The Working Group is not attempting to restore the lagoon to a specific point in time. Nor does the Working Group expect to recover previous conditions in Bolinas Lagoon or to prevent existing conditions from changing naturally.

Widespread removal of sediment in order to create subtidal habitat would alter the natural processes of the lagoon. Attempting to control or manage littoral sediment (80% of the net sediment accumulation in the lagoon) through broad-scale dredging would be ineffective and the consequences

uncertain. It is likely new sediment would return to the lagoon, replacing the excavated material. In other words, if 1.2 million cubic yards of sediment were removed from the lagoon, the ecological costs and benefits are uncertain, and the dollar amount exorbitantly high. Dredging to create subtidal habitat will not help restore natural processes within the lagoon, which is the goal of this plan. Finally, the increased rate of projected sea level rise is expected to substantially lengthen the time existing shallows remain extant.

Removal of sediment that is a result of human impacts and that promotes a naturally functioning lagoon is a possibility. The Working Group recommends sediment removal that does not require repeated human intervention. The Working Group has made recommendations to excavate sediment from the PGC Delta which may help restore subtidal and lower elevation mudflat habitats.

Although the next major earthquake will most likely deepen the lagoon, the earthquake will not address many of the human-caused changes that continue to affect Bolinas Lagoon, such as increased alluvial deposition, progradation of PGC Delta, impaired floodplains, hardened shorelines, lack of connectivity between the lagoon and adjacent habitat, stabilization of Kent Island, and sea level rise. The Working Group recognizes that the timing and affect of future natural small and large scale events (e.g., sea level rise, frequency and intensity of major storms, earthquake magnitude and timing) are uncertain and that the best way to ensure the long-term health of the lagoon is to restore the processes that allow it to evolve naturally.

Considerations of a two-channel system were discussed throughout the development of this plan. In the end the Working Group concluded the diminishment of Bolinas Channel is a result of processes occurring adjacent to the channel, and made recommendations that address the sources of sediment causing the smaller channel. The Working Group identified increased sediment supplies from PGC and stabilization of Kent Island as the main contributors to a smaller Bolinas Channel. The Working Group has made recommendations that focus on remediating human impacts in the PGC region and on Kent Island *(see Recommendation 2-LPP – Recommendations for Pine Gulch Creek region and Recommendation 7-LPP – Restore Kent Island as a dynamic flood shoal island).*

Two factors have greatly contributed to the progradation of the PGC Delta, which has affected the Bolinas Channel. First, maintenance of PGC at the Olema-Bolinas Road and MCOSD lands has helped anchor the channel location, disconnecting the channel from its floodplain. The floodplain is no longer able to absorb sediment through deposition.

Secondly, changes in management practices have contributed to the expansion of the willows and other vegetation on PGC Delta. Prior to 1970, cattle and mowers routinely roamed the delta, minimizing vegetation. Management efforts aimed at returning the PGC Delta to a more natural environment have given way to the eastward expansion of vegetation. *Recommendation 2-LPP – Recommendations for Pine Gulch Creek region* recommends the Feasibility Study and Draft EIS/EIR evaluate various scenarios for removal of unnatural levels of sedimentation when coupled with floodplain restoration. These analyses will consider if and how the excavated area of the delta may improve the hydrological function of the Bolinas Channel. Furthermore, dredging for the purpose of boating access is outside the mandate of GFNMS.

The westward expansion of Kent Island has also affected the Bolinas Channel. The Working Group recommends removal of introduced species on Kent Island *(see Recommendation 7-LPP – Restore Kent Island as a dynamic flood shoal island)*. This recommendation focuses on restoring Kent Island to a dynamic flood shoal island, which may also help to alleviate a diminishing Bolinas Channel.

The 1854 T-Sheets show the Bolinas Channel running up the far western edge of the lagoon, ending in the upper basin at a junction with PGC and the main channel. Intertidal areas (not channels) are depicted in the area that is now the upper portion of Bolinas Channel. Additionally, the main channel is much larger than Bolinas Channel at this time.

The 1929 T-Sheets reflects a realignment of the two-channel system. The main channel is still largest of the two. Bolinas Channel is not depicted on this map. Instead, a new "central" channel runs directly north from the inlet into the middle of Bolinas Lagoon, connecting to the rest of the lagoon just north of present day Kent Island.

In aerial photographs from 1959 to present, this “central” channel closes off at Kent Island and re-aligns to the upper portion of Bolinas Channel. This re-alignment can be seen in *Figures 3, 4 and 5 –* excerpts from the PWA Report (2006). The major impact of this realignment is that Bolinas Channel now connects to a location in the middle of the lagoon with higher mudflat elevations, rather than the deeper basin farther north; the gradient in tidal elevation between the head and mouth of the channel is smaller, and this gradient exists for a shorter time period during each tide, as the higher elevations in the central part of the lagoon drain quickly, compared to the deeper upper basin.

This realignment of the channel was due primarily to the seismic uplift caused in the 1906 earthquake. As the main channel has been larger than the Bolinas Channel at all times during recorded history, this channel is the primary conduit for water moving between the upper basin and the inlet. In

conclusion, it is the current recommendation of the Working Group to not dredge the lower channel based on current knowledge of lagoon function.

The historical, cultural and aesthetic values of the Bolinas Channel are recognized by the Working Group, but were not the driving force of recommendations put forth. The ecological services provided by the lagoon are invaluable to the local community and were considered by the Working Group. The Working Group believes the level of uncertainty of dredging Bolinas Channel does not warrant such ecologically disruptive actions. Furthermore, dredging to maintain a two-channel system will not help restore natural processes within the lagoon, which is the project goal. Again, the Working Group is not attempting to restore the lagoon to a specific point in time. However, the Working Group believes actions in the PGC region and on Kent Island may bring about direct improvements to the Bolinas Channel.

The Working Group has made recommendations for solutions that focus on improving hydrological functions and sediment transport mechanisms that have been altered by human activity. Adaptive management is a critical component to this approach. Adaptive management, discussed in more detail in *Section 4 - Framework for an Adaptive Management and Monitoring Program*, is a management technique that evolves from the outcomes of restoration activities and monitoring results. Successful ecosystem management requires an iterative process.

Issues Considered but not Included

After all the issues and concerns were identified, some failed to adhere to the criteria set out in *Section 1.4 – Intellectual Framework Implemented by the Working Group.* By no means were any issues or concerns discounted. Conversely, considerable thought and discussions were given to all topics placed on the table.

Seadrift Spit

Shoreline position along Seadrift Spit, relative to a 1942 baseline, is depicted in *Figure 6* – excerpts from Conceptual Littoral Sediment Budget Report (2006). These shoreline positions are based on analysis of historical aerial photographs. *Figure 6* does not show any trend in beach erosion due to installation of rock revetment in 1982 (e.g. several of the lines landward of the baseline occurred prior to 1982). While the Working Group does not discount local observations regarding loss of sand along this

beach, specifically from the areas around points B, C and D in *Figures 6 and 7* – excerpts from Conceptual Littoral Sediment Budget Report (2006), the lack of a clear trend does not provide any indication that revetment on Seadrift has affected transport into the lagoon.

It is possible that changes to the beach profile have affected current and wave dynamics in the region near the inlet; however these changes are not reflected in any available data. The placement of revetment may have affected the capacity of the Seadrift Spit to store sand, but the spit itself is not a source; the source of this sand is littoral transport from the bluffs south of Stinson Beach or offshore in Bolinas Bay. A change in storage may have contributed sand to Bolinas Lagoon, but the estimated volume of this change is small relative to the total observed loss of tidal prism. Additionally, the rate of tidal prism loss was slower between 1968 and 1998, compared to the previous period, further suggesting that the contribution of the revetment on the spit is minimal compared to other natural processes. Given the lack of an obvious shift associated with the installation of revetment in available data, the Working Group cannot conclude that this anthropogenic activity has had any quantified effect on lagoon sedimentation.

Bolinas Bluffs and Groin

The Bolinas Bluffs and the Bolinas Groin were discussed at length throughout the development of this plan. Fine-grained silt eroded by waves from the Bolinas Bluffs makes its way through the inlet and into the lagoon. Although a small fraction of silt enters the lagoon, tidal flood currents are able to transport these fine sediments far into the north and south ends of the lagoon. Although sediment from the Bolinas Bluffs is entering the lagoon, the Working Group concluded that the sediment entering into the lagoon was a natural process *(see Principle #5 – Section 1.4)* and therefore did not put forth recommendations that directly address this concern.

However, in an effort to address public concerns, the GFNMS Advisory Council Bolinas Lagoon Working Group will write a letter to the responsible agencies and organizations regarding littoral sediment entering into the lagoon from both the Bolinas Bluffs and the Seadrift Spit. The GFNMS Advisory Council Bolinas Lagoon Working Group will request a detailed investigation into the amount and sources of littoral sediment entering the lagoon and determine what, if any, actions can be taken to minimize littoral sediment entering into the lagoon.

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Section 2. Restoration recommendations in the Locally Preferred Plan

The recommendations in Table 1 constitute the Locally Preferred Plan. These recommendations will be analyzed among other alternatives in the United States Army Corps of Engineer's Bolinas Lagoon Feasibility Study and Draft EIS/EIR. These recommendations were developed through a community-based process of the GFNMS Advisory Council Bolinas Lagoon Working Group. Figure 8 provides a map of the lagoon that shows the specific locations of each recommended restoration action as listed and numbered in Table 1. For more details on the current process and future implementation strategies see *Section 5 – Conclusions.*

2.1 Objective 1: Restore natural sediment transport and ecological functions

1-LPP. ***Recommendation***: *Conduct a quantitative sediment source analysis of the Bolinas Lagoon watershed and seek remedies for problem areas.*

Human land uses including historic logging, farming, grazing, woodcutting, and road building have increased erosion and sediment availability in the watershed. The Working Group recommends that the Feasibility Study and Draft EIS/EIR conduct a quantitative sediment source analysis of the Bolinas Lagoon watershed to identify current and potential problem areas. Problem areas are those that contribute sediment into Bolinas Lagoon, including trails and roadways. Once identified, the Working Group recommends remediating the sources with the greatest potential to reduce sediment availability in the lagoon.

2-LPP. ***Recommendations for Pine Gulch Creek region***

a. *Floodplain: Reestablish the Pine Gulch Creek floodplain consistent with flood protection.*

A long history of anthropogenic activities has affected the PGC watershed. Small farms once covered much of the Pine Gulch Creek (PGC) watershed. Over twenty farms, including several dairy farms produced everything from dairy products to fruit and poultry. Today, only about 120 of the 550 acres of privately-owned and operated farmland are in active production. Land owners of this area have

taken measures to become stewards of the land, helping to preserve Bolinas Lagoon. Three of the four farms near PGC are certified Salmon-Safe and the fourth farm is working to become certified. Salmon-Safe is a program that focuses on best management practices for avoiding harm to streams and salmon populations.

Under natural conditions the Pine Gulch Creek (PGC) floodplain included the Star Route Farm, the Bolinas School grounds, Gospel Flat Farm, and other privately owned property to the east of Olema-Bolinas Road. Historically the creek moved freely over this region and during large storms the heavier bedload and some suspended sediment fell out as the creek spread over this area. In its current state, the channelized creek restricts materials from being deposited on upland areas (the floodplain), resulting in a direct deposit of material into the lagoon. The PWA Report (2006) concluded that the progradation of the PGC Delta would continue throughout the 50-year projection period.

The Working Group recommends preventing the rapid growth of the PGC Delta by increasing the volume of sediments captured on upland areas (the floodplain). Such restoration activities will protect wind-wave action, reduce the projected conversion of mudflat habitat to tidal marsh and uplands, and decelerate the loss of tidal prism.

The Working Group recommends restoration actions begin immediately on publically owned lands. The Working Group recommends eliminating man-made structures (e.g., the footbridge) and activities (e.g., removal of woody debris) and other practices that encourage PGC to remain in a fixed channel. The results of these actions on publically owned lands can be used to model and show that restoration activities can be successfully completed in a relatively short time frame. For example, while the Working Group was in session (September 2007 thru July 2008), Audubon Canyon Ranch (ARC) restored an area of Volunteer Canyon between the farmhouse and the lagoon. Full restoration of this area has yet to be completed due to limitations related to Highway 1. However, the efforts by ACR are an example of restoration actions that can be achieved in a relatively short time frame.

The current flood control management actions at Olema-Bolinas Road and MCOSD lands have affected the PGC Delta. Removing sediment from beneath the bridge at the Olema-Bolinas Road temporarily reduces flooding. However, subsequent storms carry more sediment into the affected area, resulting in repeated flooding. Consequently, clearing beneath the bridge helps keep the creek in its channel. Sediment in the creek is then deposited on the PGC Delta. Designing a floodway and/or

constructing a causeway bridge[4] over PGC at the Olema-Bolinas Road will help to reduce roadway flooding. The bridge at the Olema-Bolinas Road should be examined to determine the optimum configuration for floodplain function and public safety.

Given the farming activities and infrastructure, especially on the west-side of the Olema-Bolinas Road, activation of the floodplain is somewhat problematic. The Working Group recommends stakeholders, including the Bolinas Community Public Utility District and the PGC Association become engaged in further developments of this recommendation. Marin County should engage in conversations with landowners to investigate opportunities for a mutually agreeable floodplain restoration plan. The landowners may be interested in investigating mutually beneficial ways to manage flood waters such that farmland is enriched with creek sediments, property and structures are protected, and less sediment is carried into the lagoon. Purchasing property and flood easements from willing sellers should also be investigated.

b. *Delta: Remove a portion of the Pine Gulch Creek Delta. Delta removal must be sustainable and completed in conjunction with the floodplain restoration activities*.

The PGC Delta is made up of sediment that has resulted from anthropogenic activities. The impacts of logging and agriculture during the Gold Rush Era have greatly contributed to the development of the PGC Delta. These historic activities have afflicted the region for decades, creating an increased amount of sediment that continues to affect the natural processes of the lagoon. This build-up of sediment has led to the conversion of subtidal and lower mudflat to higher mudflat, tidal marsh and upland habitat, and a decreased tidal prism.

The PWA Report (2006) states, "continued progradation of Pine Gulch Creek (PGC) Delta…results in the increase of area sheltered from wind-waves. Due to the quiescent conditions created, sediments have accumulated in these sheltered areas allowing marsh plants to colonize the previously unvegetated mudflats.[5]" Hence, diminution of wind-wave action will continue to lead to the

[4] A causeway is a bridge between 36-40 feet wide, of various lengths. Causeways are built on concrete pilings on the same alignment as the existing roadway.

[5] Excerpt from page 29 of the PWA Report (2006).

conversion of mudflat habitat to tidal marsh between the PGC Delta and Kent Island and to a loss of tidal prism.

The Working Group recommends that the EIS/EIR evaluate various scenarios for removal of these unnatural levels of sedimentation when coupled with floodplain restoration. Additional analyses that include the quantities of sediment captured from floodplain restoration and how this affects the progradation of the delta is recommended. These analyses will determine the optimum overall acreage, depth, and slope of sediment removal at the PGC Delta. These analyses should also consider: 1) the design that best promotes wind fetch and increased wind-wave power; and 2) whether the excavated area would benefit the channel systems to promote sediment transport out of the lagoon. Careful evaluation is required as these deltas may provide ecologically valuable transitional and riparian habitat.

Activation of the PGC floodplain will slow the progradation of the PGC Delta by capturing sediment from the watershed on upland areas. Reducing the extent of the PGC Delta and slowing its progradation also has the potential to increase the availability of wind-waves which re-suspend sediments and maintain lower mudflat elevations.

3-LPP. ***Recommendation:*** *Investigate utilizing a portion of the Golden Gate National Recreation Area Stinson Beach parking lot as a seasonal floodplain for Easkoot Creek.*

The Working Group recommends that the County of Marin (Marin County Flood Control District) and the Golden Gate National Recreation Area investigate the use of GGNRA Stinson Beach lands to improve floodplain function for Easkoot Creek.

4-LPP. ***Recommendations for the Bolinas "Y" region***

a. *Floodplain: Improve floodplain functions in the area of the Bolinas "Y," consistent with flood protection.*

Lewis Creek and Wilkins Gulch Creek drain a substantial area in the north lagoon. These creeks have been rerouted, bermed and/or culverted, hindering the natural processes of the lagoon.

Lewis Creek originates within the national park-owned Rancho Baulines property, and crosses under Highway 1 north of the Bolinas "Y." Originally this creek entered at the head of the lagoon,

feeding the transitional riparian area now located between the "island" of the Bolinas "Y" and the south fork of the Bolinas 'Y" and the lagoon. The Working Group recommends realigning Lewis Creek to flow naturally into the lagoon on a more unobstructed path.

The original route of Wilkins Gulch Creek is less clear. Wilkins Gulch drains the watershed further east and may have originally drained into the Bolinas "Y." It appears to be hydrologically connected to the small brackish pond on the east-side of Highway 1. This pond is known to support the federally-threatened California red-legged frog. The Working Group recommends the EIS/EIR conduct an additional hydrological study, lead by scientist with expertise in floodplain restoration, before implementing restoration strategies on this drainage.

Carrying out these recommendations require collaboration with the National Park Service. The brackish pond on the east-side of Highway 1 is located on GGNRA managed land. Areas north of the Bolinas-Fairfax Road (including Wilkins Gulch) are on GGNRA land which is managed by Pt. Reyes National Seashore.

Successful execution of these recommendations may require constructing causeways or building small bridges that will allow for a more natural active floodplain. With sea levels rising these recommendations will allow the lagoon the ability to expand inland *(see Recommendation 9-LPP – Actively plan and manage for sea level rise at Bolinas Lagoon)*. Causeway and/or bridge construction will not add a significant amount of fill to the lagoon and will lessen the amount of hardened shoreline found at the lagoon's edge.

b. *Delta: Remove a portion of the unnatural levels of sediment from north Bolinas Lagoon (near the mouths of Lewis Creek and Wilkins Gulch Creek). Fill removal must be sustainable and completed in conjunction with improving floodplain functions.*

The 1854 T-Sheets indicate that Lewis Creek did not have high levels of unnatural sedimentation at the mouth of the creek, which is now evident. The Working Group recommends that the EIS/EIR evaluates removing the areas of unnatural sedimentation. Again, careful evaluation is required as these areas may provide ecologically valuable transitional and riparian habitat.

5-LPP. ***Recommendations for east shore, including Stinson Gulch***

a. *Floodplain: Improve floodplain functions along the eastern shore of Bolinas Lagoon consistent with flood protection.*

All of the creek floodplains on the east shore of the lagoon have been modified to various extents; at a minimum, all of the creeks have culverts that direct flow under Highway 1; others have been channelized and bermed to control water flow and protect property. The Working Group recommends the EIS/EIR evaluate the east shore drainages to determine the most cost effective and ecologically beneficial drainages to restore.

The Working Group has identified Stinson Gulch as an area of particular importance. Stinson Gulch Creek has been channelized and diverted to flow through several culverts under Highway 1. This has resulted in sediment forming a small but growing delta that has the potential to severely restrict water flow in the south lagoon. The Working Group recommends elevating Highway 1 onto a causeway, thus eliminating the culverts and allowing the creek to flow and deposit sediment across its floodplain during storm events. A causeway would also provide habitat connectivity and allow inland movement of the lagoon as sea levels rise. Causeway bridge construction will not add a significant amount of fill to the lagoon, and will lessen the amount of hardened shoreline found at the lagoon's edge. Recreating historic flow patterns will promote landscape connectivity beneath causeways that will allow the lower reaches of the creeks to flow through emergent wetlands without defined channels, which will then grade naturally into upland habitat (e.g., floodplain restoration).

b. *Delta: Prioritize removal of delta areas along the eastern shore of the lagoon. Delta removal must be sustainable and completed in coordination with improving floodplain functions.*

Again, the Working Group has identified Stinson Gulch as an area of particular importance; however this recommendation concerns all delta areas along the east shore of the lagoon. Pike County Gulch, Volunteer and Audubon Canyon, Morse and McKinnan Gulch and several other creeks have small deltas that extend into the lagoon. Many of these deltas lie along the main channel and the material is carried away by currents, precluding additional progradation. Other delta areas, such as Stinson Gulch, are more problematic. The Stinson Gulch Creek drainage is not on the main channel,

and consequently bedload and sediment build up over time. This small but growing delta has the potential to severely restrict water flow in the south lagoon.

The Working Group recommends that the EIS/EIR evaluate the ecological costs and benefits of excavating all delta areas along the east shore of the lagoon. Excavation must be sustainable and completed in conjunction with floodplain activation. Removing delta areas may provide increased tidal prism and promote intertidal habitat. As previously mentioned, careful evaluation is required as some of these deltas provide ecologically valuable transitional and riparian habitat.

6-LPP. *Recommendations for restoring habitat connectivity and transitional habitat*

Connectivity between habitats has both hydrological and ecological values. Hydrological connectivity is widely acknowledged as a fundamental property of all ecosystems and a crucial element to consider for ecosystem restoration (Kondolf *et al.* 2006). Hydrologic connectivity is also essential to the ecological integrity of the landscape (Pringle 2003). Humans have had major negative environmental effects on hydrological connectivity at Bolinas Lagoon. For example, the roadways circling the lagoon act like dams on creek drainages, present steep impermeable barriers (lagoon side), and act as barriers to habitat connectivity between wetland and transitional and upland habitats.

a. *Improve transitional habitat along the east shore of Bolinas Lagoon.*

Restoring the connectivity between the lagoon and upland habitat is critical to species whose habitat is along the periphery of the lagoon. Based on the 1854 T-Sheets, the east side drainages did not have defined channels near the lagoon. Defined channels become apparent up towards Bolinas Ridge. Recreating historic flow patterns will promote landscape connectivity beneath causeways that will allow creeks in the lower reaches to flow-through emergent wetlands without defined channels which will then grade naturally into upland habitat (e.g., floodplain restoration).

The Working Group recommends the EIS/EIR evaluate the ecological costs and benefits of improving transitional habitat along the east shore of the lagoon. With sea level rise, transitional habitat will be reduced. It is important this habitat and associated species are protected. This recommendation corresponds with activities of *Recommendation 9-LPP – Actively plan and manage for sea level rise at Bolinas Lagoon*.

b. *Improve transitional habitat along Dipsea Road.*

The hardening of surfaces along roadways reduces the potential to conserve transitional habitat. The Working Group recommends establishing transitional habitat between the open-space area along Dipsea Road and Bolinas Lagoon. This area was developed using fill, and currently a relatively steep embankment drops from the open-space plateau into the lagoon, limiting species' use of this potentially valuable habitat. The Working Group recommends the EIS/EIR evaluate the ecological costs and benefits of creating a gradual slope from the open-space area into the lagoon to improve transitional habitat along Dipsea Road. This is an opportunity to be proactive in anticipation of sea level rise and create high tide transitional upland habitat, which will be lost as the ocean rises.

7-LPP. ***Recommendation****: Restore Kent Island as a dynamic flood shoal island.*

This recommendation is two-fold, falling within the scope of objectives one and two. Kent Island, a flood shoal island, has expanded in size and is more stable than expected for such a feature. The size increase may be partially attributable to introduced species including Monterey pine, European beach grass, iceplant, and French broom that capture and stabilize the island's sands, anchoring the flood shoal island. "Kent Island is subject to colonization by introduced species. If these species continue to spread, they will have an adverse impact on the native plants of the island and could contribute to a more substantial increase in sand accretion[6]" (PWA Report 2006). Naturally, Kent Island would shift throughout the year in response to tides and wind.

The Working Group recommends that the EIS/EIR evaluate the efficacy of removing underground root masses of introduced European beach grass and aboveground introduced vegetation to restore the island's ability to naturally shift. Removing introduced species from both above and below ground may help to reestablish Kent Island as a dynamic flood shoal island and increase the sediment transport processes of the lagoon.

Adaptive management is a critical component to successfully managing Bolinas Lagoon. In the instance of Kent Island, an adaptive management recommendation has been made. If, after actions to

[6] Excerpt from page 87 of the PWA Report (2006).

remove introduced species are taken on Kent Island, the island has not become more dynamic (shifting throughout the year in response to tides and wind) and is still accessible by humans, then the removal of the peninsular "neck" of Kent Island should be examined. The Working Group believes this will aid in restoring Kent Island to a dynamic flood shoal island, as well as help to discourage humans from disturbing harbor seal haul-out sites. These actions are to be considered if the removal of introduced species on Kent Island and actions in the PGC region result in no change.

8-LPP. ***Recommendation****: Investigate managing tidal exchange of Seadrift Lagoon.*

In an effort to increase water circulation in the south lagoon, the Working Group recommends the EIS/EIR investigates managing tidal exchange between Seadrift and Bolinas Lagoons, focusing on non-structural or passive approaches, if possible. This investigation needs to ask the question: Will managed tidal exchange promote circulation and tidal scour in the south lagoon, thereby decreasing sediment retention? The study needs to identify whether such action is feasible and ecologically viable.

This recommendation is based on the premise that managing tidal exchange between Bolinas and Seadrift Lagoons during extreme high-tides will create a tidal head that promotes circulation within the southern portion of Bolinas Lagoon.

9-LPP. ***Recommendation***: *Actively plan and manage for sea level rise at Bolinas Lagoon.*

In anticipation of sea level rise, the Working Group recommends two actions: 1) Develop a model to reflect the consequences of sea level rise for Bolinas Lagoon; and 2) Reduce the dam-like effects of roadways bordering the lagoon to support tidal and fluvial processes. Sea level rise provides an opportunity for the lagoon to increase in size by expanding inland but has the potential to negatively affect property owners and adjacent transportation infrastructure. The lagoon has naturally moved inland with sea level rise over the last 8,000 years, and now it cannot move further inland due to the hardening of the lagoon's perimeter.

Models are needed to make advance planning decisions. Sea level rise projections can define areas where the lagoon could be allowed to expand and where land acquisitions would benefit both the land owner and the lagoon. The Working Group recommends that the EIS/EIR reevaluates the 50-year projection in the PWA Report (2006) using the most recent sea level rise information to determine how

tidal prism and habitat shifts would be expected to change. The Working Group recommends mapping the lagoon perimeter to identify areas that will be most impacted by sea level rise. For example, the affects of +1, +2 and +3 feet rise in sea level need to be mapped. Furthermore, MCOSD is encouraged to work with landowners adjacent to the lagoon to find solutions that avoid additional hardening of the lagoon's shoreline. The Working Group recommends that MCOSD and GFNMS work closely with willing landowners and Caltrans to proactively plan for sea level rise.

The Working Group recommends reducing the dam-like effects of roadways bordering the lagoon to support tidal and fluvial processes. In coordination with the development of this document, Caltrans conducted an assessment of the culverts along State Highway 1 between mile posts 12.79 and 17.01. Each culvert was prioritized for replacement based on Caltrans maintenance standards or materially failed culverts (prioritization may change if upstream areas are restored to more natural floodplain functions). The County and Caltrans should plan for roadway and culvert improvements, including possible elevation of roadways to reduce impacts to the lagoon and improve habitat connectivity.

The Working Group recommends replacing portions of Highway 1 with causeway bridges[7]. Causeway bridges can be used to elevate and protect areas of Highway 1 that are threatened by rising sea water. Construction of causeways will not increase fill in the lagoon. In some areas, the Working Group recognizes culvert replacement may be a more suitable recommendation. Constructing causeways over drainages will increase hydrological connectivity, reestablish the natural floodplain, and address concerns of sea level rise. Causeways will also allow the lagoon to move inward with sea level rise and minimize the need for extensive fill required to elevate roadways on a solid base. Causeway bridges also eliminate the need for culverts that will require constant repositioning as higher water levels fill the lagoon.

[7] A causeway is a bridge between 36-40 feet wide, of various lengths. Causeways are built on concrete pilings on the same alignment as the existing roadway.

10-LPP. ***Recommendation****: Model suitable habitat for eelgrass and restore in appropriate areas.*

Eelgrass is an extremely valuable habitat for invertebrates and fish. Eelgrass serves as a nursery ground for larvae and juvenile fish and provides protection from predation by bigger fish and birds. Eelgrass contributes to the health and productivity of the coastal environment and is protected under section 404 of the Clean Water Act. Eelgrass has been designated as an Essential Fish Habitat under the Magnuson-Stevens Fishery Conservation Management Act.

Currently it is uncertain why eelgrass has largely disappeared from Bolinas Lagoon. Further investigation is needed to determine if there is habitat suitable for eelgrass in the lagoon. If the results of the investigation find suitable habitat, eelgrass restoration should be attempted providing it will not have detrimental effects on sediment transport within the lagoon. If so determined, it is recommended that eelgrass be restored, to the extent possible, consistent with the natural evolutionary trajectory of the lagoon. The Working Group recommends attempting reintroduction at the most promising locations but if efforts fail, further reintroduction is not recommended. The Working Group recognizes that after other recommended actions are undertaken, suitable eelgrass habitat may become available.

2.2 Objective 2: Identify and manage introduced species

Introduced species are one of the most serious environmental problems of the twenty-first century (Sala *et al.* 2000; Holloran *et al.* 2004). Introduced species crowd out native plants, insects, and small mammals and disrupt natural processes. Wildlife habitat can be significantly degraded by introduced species. Many introduced plant species form dense stands that push out native plant species and reduce food and shelter needed by native wildlife, including endangered species. Although the abundance and diversity of species may increase, the habitat quality and ecosystem health decline.

Several introduced species are currently found in the Bolinas Lagoon watershed. It is important to manage these species in an effort to thwart further growth and expansion and improve habitat for native species. An Early Detection and Rapid Response Program is recommended for Bolinas Lagoon and its watershed. The Early Detection and Rapid Response Program will provide a species list of possible invaders, the level of effort appropriate to control each species and the best method to manage each species. If possible, introduced species will be eradicated using the best available methods or if complete eradication is not possible, then an active management plan will be considered.

Implementation of this recommendation requires collaboration among public agencies, non-governmental organizations and private landowners including: Marin Municipal Water District, the Marin-Sonoma Weed Management Area, Marin County Open Space District, California Invasive Plant Council, Golden Gate National Recreation Area, Point Reyes National Seashore, and Audubon Canyon Ranch. Additionally, California Department of Fish and Game, which has authority over introduced estuarine and freshwater animal species is a necessary collaborator.

11-LPP. ***Recommendation***: *Prioritize, remove, and manage all introduced species on Kent Island.*

In addition to the possible benefits of restoring Kent Island as a dynamic flood shoal island *(see Recommendation 7-LPP – Restore Kent Island as a dynamic flood shoal island)*, removing introduced vegetation will have positive benefits for native plant species. Once the introduced plant species are removed from Kent Island, colonization in the eradicated areas by native plants will likely follow (Grosholz pers. comm.). Native dune plant species easily adapt to shifting conditions and are better suited for dynamic rather than fixed environments as opposed to introduced plant species. Once removed, introduced plant species on Kent Island will need to be monitored in order to impede future expansion.

2.3 Objective 3: Protect water quality

Protecting the water quality of Bolinas Lagoon goes beyond the lagoon's shoreline. Runoff flowing from the watershed can accumulate pollutants which are a leading cause of water quality degradation (USEPA 2008). Runoff from forests and agricultural land can wash pollutants such as sediment, pesticides and bacteria downstream and into the lagoon and coastal waters. Sediment from eroded banks and slopes, leakage from septic or sewage systems, and old dump sites are non-point source contaminants that negatively affect water quality. Protecting the water quality of Bolinas Lagoon will enhance the lagoon's chemical, physical, and biological integrity (USEPA 2008).

Human land uses including historic logging, farming, grazing, woodcutting, and road building may have caused sediment contamination, particularly, the historic copper mining near PGC. At Rodeo Lagoon, Golden Gate National Recreation Area found elevated metal concentrations associated with road culverts. The Working Group recommends the EIS/EIR tests for sediment contamination

throughout the Bolinas Lagoon watershed. Sources contributing to elevated levels of contaminated sediment need to be remediated. This recommendation may be conducted simultaneously along with *Recommendation 1-LPP – Conduct a quantitative sediment source analysis of the Bolinas Lagoon watershed and seek remedies for problem areas*.

12-LPP. ***Recommendation****: Remove treated woody debris from Bolinas Lagoon*.

Treated woody debris and non-functional utility infrastructure found in the lagoon need to be removed. Woody debris carried in by tidal currents or purposely placed in the lagoon (e.g., old telephone/utility poles) has most likely been previously treated with a preservative, such as creosote or other contaminants. Creosote is a pesticide used to preserve wood against rot. The chemicals used to preserve the wood do not degrade but rather persist in the environment. The contaminants may threaten the water quality of Bolinas Lagoon; therefore, the Working Group recommends treated woody debris found in Bolinas Lagoon be removed. The NEPA analysis will evaluate the ecological costs and benefits of removing treated woody debris from Bolinas Lagoon.

13-LPP. ***Recommendation****: Investigate and if feasible, remove dump sites in Bolinas Lagoon*.

Contaminated sediments can have acute and chronic effects on aquatic life (Armitage 1997). Adverse ecological effects of contaminants in sediment include: fin rot, skin lesions, increased tumor frequency, and reproductive toxicity in fish; reproductive failure in fish-eating birds and mammals; and decreased biodiversity in aquatic ecosystems (Armitage 1997).

Three old dump sites have been identified along the western/northwestern shore of Bolinas Lagoon. The Working Group recommends the EIS/EIR investigate, and if feasible, remove the old dump sites. Dump sites may also contain potentially sensitive archeological resources that may require investigation and consideration prior to removal. There is uncertainty of the extent to which these old dump sites are affecting the water quality and biota of Bolinas Lagoon. If contaminants are associated with the old dump sites and warrant removal, careful consideration must be given to the risks posed by the contaminants, the ecological benefits of the remediation, and the costs. These dump sites have been present in Bolinas Lagoon for years, and the associated pollutants, if agitated, may cause more harm than if left alone.

14-LPP. ***Recommendation****: Investigate water quality violations concerning septic and sewage systems throughout the Bolinas Lagoon watershed and remediate.*

Human activities along the coast can influence the quality of fresh and saline groundwaters discharging along the coastline at the land-sea interface (Burnett *et al.* 2006). This discharge is defined as submarine groundwater discharge (SGD). SGD can contribute nutrients, metals, pollutants, and freshwater to the coastal environment (Johannes 1980; Bone et al. 2007). Near Bolinas Lagoon (Stinson Beach), de Sieyes *et al.* (2007) found that high nutrient concentrations in fresh groundwater are due at least in part to contamination by septic effluent. The Working Group recommends the EIS/EIR investigates water quality violations pertaining to septic and sewage systems within the Bolinas Lagoon watershed.

Eutrophication can affect the ecological function of the lagoon and if SGD entering into Bolinas Lagoon carries high levels of pollutants eutrophication may persists. The Working Group also recommends regular water quality monitoring.

Section 3. Management Recommendations for Bolinas Lagoon

This section includes management recommendations that can be conducted independently of the Bolinas Lagoon Ecosystem Restoration Feasibility Study and Draft EIS/EIR (Table 2). The success of these recommendations is dependent on the collaboration and/or consent of many agencies (e.g., Point Reyes National Seashore, Golden Gate National Recreation Area) and organizations (e.g., Audubon Canyon Ranch) that manage lands adjacent to the lagoon; including Gulf of the Farallones National Marine Sanctuary (GFNMS) and Marin County Open Space District (MCOSD) — partner agencies responsible for the lagoon's day to day management.

Implementation of these recommendations are subject to GFNMS's and MCOSD's priorities, funding availability, and the satisfaction of federal, state and local environmental review requirements. Because MCOSD's land management authority is limited to its own lands, implementation of some recommendations affecting lands not owned by MCOSD or the County of Marin may require the involvement of other public agencies and the cooperation of private landowners.

Management recommendations include: implementing best management practices throughout the Bolinas Lagoon watershed, removing fallen trees from the lagoon, establishing a responsible wildlife viewing program, and developing an emergency response plan in the event of an inlet closure. Other recommendations focus on managing introduced species throughout the Bolinas Lagoon watershed and protecting the lagoon's water quality.

3.1 Objective 1: Restore natural sediment transport and ecological functions

The following recommendations are to be considered in an effort to reduce or slow anthropogenic influences that are affecting the natural sediment transport and ecological functions of Bolinas Lagoon.

1-MG. *Recommendations for Best Management Practices*

Implementing Best Management Practices (BMPs) throughout the Bolinas Lagoon watershed, as prescribed by Marin County, will aid in reducing non-point source pollution to Bolinas Lagoon. The Community Development Agency of Marin County recently released (November 2007) the Countywide

General Plan (http://www.co.marin.ca.us/depts/cd/main/fm/TOC.cfm), which outlines land use practices. Section 2, Natural Systems & Agriculture Element of the Countywide Plan "contains policies intended to preserve native habitat and protect sensitive resources through appropriate land use practices…Sensitive resources include jurisdictional wetlands, occurrences of special-status species, occurrences of sensitive natural communities, wildlife nurseries and nesting areas, and wildlife movement corridors."

Land owners in the Pine Gulch Creek (PGC) region are actively engaged in the implementation of BMPs. The four farms in the PGC watershed are Certified Organic by the United States Department of Agriculture through the County of Marin Agriculture Department. The annual certification inspection reviews erosion control, compost management, water conservation, and wildlife habitat on each farm.

a. *Promote BMPs for farming, ranching and residential areas, including the Bolinas Bluffs.*

The Working Group recommends promoting BMPs as prescribed by Marin County throughout the Bolinas Lagoon watershed, including farming, ranching, and residential areas. Once implemented, BMPs may lead to a reduction in sediment availability and potential pollution (runoff, fertilizer, pesticides) from the watershed, including the residential area of the Bolinas Bluffs. Currently, concerned residents living in the area of the Bolinas Bluffs follow BMPs, but as the bluffs naturally erode, it is unknown if BMPs will have an affect on reducing erosion in this area.

b. *Work with stream-side property owners to protect summer flows throughout the Bolinas Lagoon watershed (Pine Gulch Creek & Easkoot Creek).*

Creeks in the watershed experience low summer flows or are ephemeral. Water flows in late summer may be critical for sustaining aquatic resources including special status species such as steelhead, coho, and California red-legged frogs. The Working Group recommends that the County and California Department of Fish and Game work with stream-side property owners to assure protection of summer flow throughout the Bolinas Lagoon watershed.

For the past eleven years, the PGC Association has maintained a strong working relationship with fisheries biologist and other staff from the Point Reyes National Seashore in a joint effort to monitor and enhance the habitat of PGC.

c. *Protect floodplain functions of Easkoot Creek through the implementation of an education program.*

The Working Group recommends protecting the Easkoot Creek floodplain through the establishment of an education campaign. Once the results of the quantitative sediment source analysis *(see Recommendation 1-LPP – Conduct a quantitative sediment source analysis)* are available, and if problem areas are identified in the Easkoot Creek watershed an education campaign to help address these areas should be implemented.

d. *Ensure BMPs for protecting native and controlling introduced species populations during restoration activities*.

Restoration activities have the potential to open up areas to invasive species. BMPs, as prescribed by Marin County, are recommended for protecting native species and controlling introduced species populations during restoration activities, particularly in riparian areas of Pine Gulch Creek (PGC). Cape Ivy, found in the riparian area of PGC, rapidly spreads and climbing native shrubs and trees, forming a solid layer that blocks out light and smothers other vegetation, threatening the diversity of the riparian understory.

Introduced invertebrate species can threaten the ecological balance of estuaries (Kennish 1999). Introduced species can outcompete native species, disrupting the ecosystem, and in extreme cases cause local extinction (Byers 1999). Predation by the more aggressive introduced species can lead to a decline in the diversity of native invertebrate species (Kelly 2005). Implementing BMPs during restoration activities will help to alleviate the potential for introduced species to colonize areas of restoration.

2-MG. ***Recommendation****: Remove introduced tree species that fall into the lagoon. Identify and remove potential tree hazards (introduced tree species).*

This recommendation targets the area along the Olema-Bolinas Road, just north of the MCOSD managed lands (Pine Gulch Creek Delta). The Working Group recommends removing Eucalyptus trees that fall or have the potential to fall into the lagoon. Downed trees or trees that have the potential to fall into the lagoon can affect the natural sediment transport of Bolinas Lagoon by acting as dams and

sediment traps. For example, several large trees that fell in the Bolinas Channel may have contributed to the rapid sediment accumulation in the area. When it is not feasible to remove fallen trees, the trees should be cut to minimize their ability to act as a barrier to sediment transport.

The Working Group recognizes the importance of downed trees and woody debris in the creeks as they provide important components of salmonid (and other fish) habitat. In some instances, a more comprehensive evaluation of the ecological costs and benefits of large tree removal from along the lagoon may be necessary based on location, benefits, and risks.

3-MG. ***Recommendation****: Establish a long-term responsible wildlife viewing program*.

Bolinas Lagoon is home to harbor seals that use the lagoon as a pupping ground and a year-round haul-out site. The Working Group recommends GFNMS implements a long-term responsible wildlife viewing program to help minimize the adverse human impact (i.e., wildlife disturbance) placed on harbor seals and other wildlife in Bolinas Lagoon. The program should focus on marine mammals and bird species. Target audiences for this recommendation include residents, visitors and outdoor enthusiasts who use the lagoon as a recreational site.

4-MG. ***Recommendation****: Develop an emergency response/contingency plan in the event of a Bolinas inlet closure*.

Closure of the lagoon's inlet would present a threat to people, property, and the lagoon's biota. Bottom-layers in the water column of the lagoon may become anoxic within a few days if the inlet closure persists (Martini-Lamb *et al.* 2005). These anoxic conditions may adversely affect harbor seals, salmonids, other fish, and macroinvertebrates.

To address this threat, the Working Group recommends the required state and federal regulatory agencies (i.e., GFNMS, MCOSD, CCC, NMFS, CDFG, and the Corps) collaborate to develop a plan to breach a Bolinas inlet closure. Once the plan is complete, permits should be sought from the appropriate regulatory agencies. With the necessary consultation and permitting in place, an emergency plan would enable agencies to breach the sandbar within days of its closure, alleviating potential flooding of low-lying shoreline properties, in addition to minimizing potential adverse impacts to the ecosystem.

3.2 Objective 2: Identify and manage introduced species

Introduced species crowd out native plants and disrupt natural processes. If new and threatening introduced species are found, there needs to be a rapid response plan involving partner agencies to quickly develop and execute an eradication program, if possible. Implementing this recommendation requires collaboration among public agencies, non-governmental organizations and private landowners *(see Section 2.2 – Identify and manage introduced species)*.

5-MG. ***Recommendation****: Immediately remove introduced cordgrass found in Bolinas Lagoon*.

In November, 2001, a single *Spartina alterniflora* clone was discovered in Bolinas Lagoon. A survey of the lagoon was organized, and no other invasive *Spartina* was found. In January 2003 an additional clone was found at the south end of the lagoon. The San Francisco Estuary Invasive Spartina Project worked with the landowner to eradicate the plant. The plant was covered with geotextile fabric in 2004 and was found to be eradicated in fall 2005.

The establishment of introduced *Spartina spp.* can significantly alter marsh hydrology, composition and structure (Levin *et al.* 2006; Neira *et al.* 2006). Invasive *Spartina spp.* grows at lower elevations and therefore is a significant threat to shallow mudflat habitat found throughout Bolinas Lagoon. Native *Spartina foliosa* populations may become threatened if introduced *Spartina spp.* are not immediately eradicated.

6-MG. ***Recommendation****: Remove introduced plant and invertebrate species found in the Bolinas Lagoon watershed.*

Removal of introduced species needs to be a major emphasis of all landowners in the watershed including: National Park Service, Audubon Canyon Ranch, State Parks, Marin County, and private landowners. Field surveys in Bolinas Lagoon, conducted in coordination with the development of the PWA Report (2006), observed six introduced plant species that are on the California Invasive Plant Council List 1-A (Table 4). These introduced species are known to be aggressive invaders that displace natives and disrupt natural habitats. Annual monitoring throughout Bolinas Lagoon and its watershed for early detection of newly introduced species is necessary.

Implementation of control efforts for introduced invertebrate species is recommended, especially for Japanese mud snail, European green crab and Gem clam, provided removal activities do not increase nonnative populations. Means of addressing introduced invertebrate species is challenging. Some control efforts may include early detection (monitoring), trapping, volunteer removal programs, and public education.

The Working Group recommends the development of a coordinated response plan that includes outlining responsibilities and authorities of partner agencies. This would permit rapid action and quick implementation of eradication measures if a new and threatening introduced species is detected.

3.3 Objective 3: Protect water quality

Protecting the water quality of Bolinas Lagoon is important to the lagoon's chemical, physical, and biological integrity (USEPA 2008). S*ee Section 2.3 – Protect water quality* for more details.

7-MG. ***Recommendation****: Develop a local oil spill response plan for Bolinas Lagoon.*

Due to the proximity of Bolinas Lagoon to the busy maritime ports and harbors in San Francisco Bay and the presence of major vessel traffic lanes, there is a high risk of oil and/or other hazardous material spills. Oil spills can pose serious threats to intertidal communities, seabirds and marine mammals. Socioeconomic impacts to commercial and recreational industries such as fishing and wildlife viewing/tourism can arise as the result of an oil spill.

In an effort to protect Bolinas Lagoon, local, state and federal agencies must develop a local oil spill response plan for Bolinas Lagoon that is coordinated with the San Francisco Area Contingency Plan. MCOSD is in the process of developing this plan, which was tested July 2008. The response plan incorporates the knowledge of the local community, as well as that of experienced professionals who are trained in deploying rapid water booms.

8-MG. ***Recommendation****: Replace toxic-impregnated materials in Bolinas Lagoon.*

It is recommended that toxic-impregnated materials (e.g., docks) in Bolinas Lagoon be replaced with environmentally friendly products. These replacements should occur during regular upgrade cycles. Replacing toxic-impregnated materials will help to protect the water quality of Bolinas Lagoon by eliminating potential sources of contaminants.

9-MG. ***Recommendation****: Promote use of public restroom facilities through an education program*.

The Working Group recommends educating recreational users on the availability of bathroom facilities throughout the Bolinas Lagoon area. Outdoor enthusiasts enjoying Bolinas Lagoon often find themselves using road-side areas for bio-breaks. This results in the introduction of pathogens into the watershed, which eventually ends up in the lagoon. Educating these visitors about the importance of using restroom facilities will help to reduce the level of pathogens entering the lagoon.

10-MG. ***Recommendation****: Identify toxins associated with the abandoned dredge and remove if feasible*.

The Working Group recommends an investigation of the toxins associated with the abandoned dredge. If feasible, removal of the dredge may follow the investigation. If contaminants are associated with the dredge, careful consideration must be given to the risks posed by agitating the contaminants. The dredge has been present in Bolinas Lagoon for almost 40 years, and the associated pollutants, if agitated, may cause more damage to the water quality of Bolinas Lagoon than if left alone.

However, if removed, the Working Group recommends using the site of the abandoned dredge as an experimental tidal basin to monitor colonization or use of the area by native and introduced invertebrates. On a small experimental level, monitoring the invertebrates in this area may provide information on the probability of invasions by introduced invertebrates following dredging activities.

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Section 4. Framework for an Adaptive Management and Monitoring Program

4.1 Adaptive Management

Conservation efforts aimed at lessening environmental degradation and habitat loss require a monitoring and evaluation component. Monitoring and evaluation helps to ensure that: 1) program goals and objectives are achieved; 2) proper feedback and information about the actions are collected; and 3) ideas to improve the effectiveness of the actions are considered (Salafsky *et al.* 2002). Adaptive management provides resource managers with the tools necessary to make informed decisions; however this approach is contingent on the iterative process in which projects are continually reassessed (Salafsky *et al.* 2001).

Determining which indicators or evaluation techniques will return the most beneficial results is a balance of feasibility, cost-effectiveness, and suitability (Margoluis & Salasky 1998). The most effective indicators are often linked to program goals, objectives, and activities (Herweg *et al.* 1998; Margoluis & Salafsky 1998). However, what may be an effective indicator for one objective may not adequately measure the outcomes of another objective. Each objective is best evaluated when linked to individual sets of effectiveness measures. Four criteria for selecting good indicators include: 1) Measurability – Can the indicators be recorded and analyzed quantitatively or qualitatively? 2) Precision – Are the indicators uniformly defined? 3) Consistency – Are the indicators able to withstand change over time, always measuring the same thing? 4) Sensitivity – Do the indicators change proportionately in response to actual changes in the condition of the item being measured (Margoluis & Salafsky 1998)?

4.2 Monitoring

Two levels of monitoring have been identified: project monitoring and monitoring for ecosystem health. The recommended conservation actions will require monitoring in order to measure the effectiveness of each project. As part of the United States Army Corps of Engineer's Bolinas Lagoon Feasibility Study and Draft EIS/EIR, monitoring protocols will be developed for each restoration action and will include metrics, success standards and goals, timelines for meeting each goal, and contingency measures if sufficient progress is not demonstrated in meeting the success standards.

Collecting information on changes in the distribution and abundance of taxa is highly recommended. Other than birds (Beach Watch Program of GFNMS and PRBO Conservation Science) and marine mammals (Point Reyes National Seashore), there are no long-term, consistently collected datasets for species of Bolinas Lagoon. Invertebrates, fish, plants, and introduced species need to be regularly monitored.

Table 3 lists some monitoring and adaptive management recommendations. Due to time constraints the adaptive management and monitoring program was not fully developed; however a preliminary framework identifying key habitats and physical processes of Bolinas Lagoon was established.

Key habitats of Bolinas Lagoon are defined in Table 5. A summary of key physical processes is identified in Table 6. Any actions recommended by the Working Group would have performance indicators that may or may not include some of the indicators intended to monitor the physical system of the lagoon (Table 6). These indicators would either help track changes in key physical processes that control the distribution and abundance of key habitats or they directly track habitat change.

Regular monitoring to track changes will prove valuable in understanding the most important cause-and-effect linkages between physical processes and the ecological functions of Bolinas Lagoon. One of the most important components to successfully monitoring and adaptively managing the lagoon is the deployment of a permanent and reliable tide gauge. Also, regular bathymetric surveys will help to document changes within the lagoon.

Section 5. Conclusions

5.1 Current Process and Public Involvement

In December 2006, the Executive Committee, a formal group that oversees budgetary and project management issues for the Bolinas Lagoon Ecosystem Restoration Feasibility Study recommended that the Marin County Board of Supervisors continue the Bolinas Lagoon Feasibility Study and Draft EIS/EIR process and develop a revised Locally Preferred Plan based on the findings from the PWA Report (2006). The MCOSD and the Corps invited GFNMS to participate in and take the lead on a public process to develop the Locally Preferred Plan. In August 2007 the GFNMS Superintendent assembled a Working Group of the GFNMS Advisory Council. The Working Group was comprised of scientists, local stakeholders, environmental groups, and state and federal agency representatives. A public meeting was held on September 19, 2007, which introduced the project, answered questions and addressed concerns of community members and local stakeholders. Table 7 is a timeline of this process.

Eight public Working Group meetings were held from September 20, 2007 to June 25, 2008. All Working Group meetings were open to the public and two 10-minute comment periods were set aside each meeting. The public was invited by the meeting facilitator to offer comments on agenda items. Through Working Group meetings a project goal, three objectives and a suite of recommended actions were formulated. The Working Group forwarded draft recommendations to the full GFNMS Advisory Council for preliminary discussion and action on April 18, 2008. The Advisory Council reviewed, discussed and supported further development of the recommendations.

A draft document was released for public comment on May 20, 2008. Comments were accepted from May 20, 2008 to June 22, 2008. A Public Workshop was held at the Stinson Beach Community Center on June 11, 2008. Following the comment period, comments were compiled and presented to the Working Group. The Working Group convened on June 25, 2008 for a final meeting to consider revisions to the plan.

This document constitutes the Working Group's final recommendations that were forwarded to the full GFNMS Advisory Council for discussion and action on July 25, 2008. The Advisory Council reviewed, discussed and forwarded the recommendations to the GFNMS Superintendent. The GFNMS Superintendent forwarded the final recommendations onto MCOSD and the Corps in August 2008.

5.2 Implementation Strategies and Project Timeline

Once a Locally Preferred Plan is identified and approved by the Executive Committee the plan will be evaluated as one of the alternatives within the Bolinas Lagoon Feasibility Study and Draft EIS/EIR. It is likely that a substantial revision of the previous Feasibility Study and Draft EIS/EIR will be necessary.

The Locally Preferred Plan will be compared to the "Without-Project" conditions and to other alternative plans. The "Without-Project" condition should be similar to the PWA Report (2006). The alternative plans, including the Locally Preferred Plan, will be analyzed for cost-effectiveness and then compared to each other. This comparison allows the Corps to identify the National Ecosystem Restoration Plan[8]. Generally, the National Ecosystem Restoration Plan is the basis for full Federal Corps participation, and a Locally Preferred Plan is usually selected as the recommended plan.

If the selected plan is substantially different than what was recommended in the 2002 Draft Feasibility Study and Draft EIS/EIR then the Corps will need to conduct another Alternative Formulation Briefing with their Headquarters and likely another public review of a new or supplemental Draft EIS/EIR.

If the selected plan is generally consistent with the 2002 Draft Bolinas Lagoon Ecosystem Restoration Feasibility Study and Draft EIS/EIR, then the Corps will proceed forward without holding another Alternative Formulation Briefing and may not need to conduct another public review of the Draft EIS/EIR. The Corps will also need to revisit assumptions and conclusions of the future "Without-Project" condition and may need to formulate additional alternative Plans if conditions, objectives, and constraints have changed since 2002.

Completion of the Bolinas Lagoon Ecosystem Restoration Feasibility Study will take approximately one to three years (the Corps per. comm.).

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[8] The National Ecosystem Restoration (NER) Plan, as described by the Corps, reasonably maximizes ecosystem restoration benefits compared to costs and is consistent with protecting the nation's environment. The NER Plan must be shown to be cost effective and able to achieve the desired level of outputs.

5.3 Overarching Challenges

Several issues need to be considered prior to implementing any of the recommended conservation actions. One of the most important hurdles to overcome is the lack of project funding. Funding for the Bolinas Lagoon Ecosystem Restoration Feasibility Study was not allocated by Congress or Federal agencies in 2008. However, with consensus on a Locally Preferred Plan, there may be greater potential to receive funding in the future, not only through the cost sharing agreement between the Corps, the State Coastal Conservancy and MCOSD, but also from other public and private sources.

Other challenges involve jurisdictional and regulatory issues. Floodplain areas may not be property owned by MCOSD or the County of Marin. This may require MCOSD to purchase flood easements from willing landowners. In cases where the property is owned by a government agency, successful floodplain restoration may depend on agency cooperation. The Federal Emergency Management Agency has guidelines for floodplain management that direct federal agencies to reduce the risk of flood loss and to minimize the impact of floods on human safety, health and welfare, as well as to restore and preserve the natural and beneficial values served by floodplains.

State threatened and fully protected species, such as the Black rail, and federally-threatened species, like the California red-legged frog, may be present in areas of proposed restoration activities. Impacts to the breeding and foraging habitats of these species must be avoided, minimized, or mitigated to the extent practicable.

5.4 Future of Bolinas Lagoon

This document is the result of government agencies, community representatives, and scientists coming together to create a vision for Bolinas Lagoon. By implementing the actions identified in this plan and practicing adaptive management, Bolinas Lagoon will thrive as an estuary of international-significance.

Acknowledgements

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Appendix

I. Response to Comments

What are the impacts of beach armoring along Stinson Beach and Bolinas Bluffs and of the groin on sediment accumulation in the lagoon?

The Conceptual Littoral Sediment Budget Report (2006) addressed the following questions:

1) Have the Bolinas groin and armoring at Seadrift affected net sedimentation in the lagoon?

Short answer: No.

2) How have these structures changed the beaches adjacent to the inlet and the movement of sand?

Short answer: Not significantly.

Their conclusions from the Conceptual Littoral Sediment Budget Report (2006) are as follows:

- Bolinas Lagoon is located within a littoral cell that extends from Duxbury Reef in the north to Rocky Point in the south. Mineralogical studies show that bottom sediments in Bolinas Bay are similar to those along San Francisco Bar, indicating that the material is either transported northward by deep coastal currents or was deposited by geologic process when sea level was much lower and sand moved along the continental shelf under the influence of waves. A portion of the bottom sediments is derived locally by erosion along the Bolinas bluffs, discharge from Webb Creek, and export from Bolinas Lagoon during ebb tides.
- Seasonal changes in wave climate and the occurrence of strong El Nino winter storms are the primary causes of fluctuations in beach width. Seasonal changes of up to 130 ft at Stinson Beach are typical, with beach widths at a maximum during summer and smaller in winter. GIS analysis of historic photographs shows that strong El Nino events also contribute to the variability in beach width.
- Stinson Beach has recovered relatively quickly following past winter storms, indicating that most of the sand eroded from the beach is stored offshore in subtidal bars and later moved shoreward when the wave climate moderates. Permanent losses of sand to deep portions of Bolinas Bay during winter storms are probably small.
- A properly functioning Bolinas groin partially traps longshore drift directed toward the inlet and is effective at increasing the size of Brighton Beach. However, the effects of the groin on coastal processes are limited due to its relatively low elevation and short length. Wave breaking around the

tip of the groin and inundation at high tide demonstrate that sand bypasses the structure once the beach builds-up to its equilibrium size.

- Waves reflected from riprap along Seadrift Beach focus wave power along the nearshore and have the potential to lower the equilibrium beach profile. A lower beach elevation increases wave attack on the structure, especially at its toe where PWA staff observed dislodged rocks during a field visit in January 2004. Although a mechanism for reducing longshore transport has been identified (i.e., lowering of the beach by wave focusing), data reviewed by PWA do not reveal any change in beach morphology due to installation of the riprap, and its effects on existing rates of longshore transport are expected to be minor.
- Construction of bulkheads along the lagoon side of Seadrift has created a less dynamic channel system. Evidence of strong erosion potential is evident along the sandy banks of the channel immediately adjacent to the bulkheads. Although installation of bulkheads along Seadrift had reduced the potential for the channel to erode through Stinson Spit and 'break-out' at a new inlet location, its effects on the long-term delivery of beach sands into the lagoon are limited since any new tidal inlet would quickly migrate westward to its present location in response to the longshore transport along the spit, which is directed from Stinson Beach toward the Bolinas Inlet.

In an effort to address public concerns, the GFNMS Advisory Council Bolinas Lagoon Working Group will write a letter to the responsible agencies and organizations regarding littoral sediment entering into the lagoon from both the Bolinas Bluffs and the Seadrift Spit. The GFNMS Advisory Council Bolinas Lagoon Working Group will request a detailed investigation into the amount and sources of littoral sediment entering the lagoon and determine what, if any, actions can be taken to minimize littoral sediment entering into the lagoon.

Describe the timing of floodplain restoration and sediment removal?

Some floodplain actions may precede sediment removal but others — for example, those that may entail longer term planning, permitting, and collaboration with private landowners — may be accomplished at the same time as part of the same sediment removal project. The Working Group recommends that the EIS/EIR conduct an additional hydrological study led by scientists with expertise in floodplain restoration. The study should evaluate the efficacy of floodplain restoration at Pine Gulch and other creeks and assess how much sediment could be captured on upland areas under different scenarios. Part of the study would be to determine how the effects of past channelization could be

rectified; how the native riparian vegetation interacts with the creek and affects floodplain functions and creek movement; how the dense understory of introduced vegetation impacts restoration objectives and habitat values; and how floodplain activation could work in various areas (e.g., the delta east of the Olema-Bolinas Road, the farmland west of the Olema-Bolinas Road if farmers were willing); and how flood control issues can be addressed.

The decision on location, aerial extent, overall depth and contour for sediment removal would be based, on the calculation of sediment captured on the restored floodplain. It is important to point out that one of the goals of the Locally Preferred Plan is sustainability, meaning that the Working Group has made recommendations for actions that do not require repetition to maintain the desired state.

Why has the Bolinas Channel decreased in size? Why doesn't the Locally Preferred Plan do more to restore the historic two-channel system?

Bolinas Channel has decreased in size when compared to that shown on the 1854 T-Sheets which shows a large channel between Wharf Road and Kent Island, dividing into one channel along the western lagoon edge and one curving to the east north of Kent Island. The 50-year projection identifies sediment accumulation and growth of tidal marsh between Pine Gulch Creek Delta and Kent Island — caused in part by the progradation of Pine Gulch Creek Delta and reduction in wind wave energy — as a primary reason for the diminution of the Bolinas Channel. Other factors that may contribute are seismic uplift on the western side of the San Andreas Fault and the colonization of Kent Island by Monterey pine tress and introduced plants that anchor the western point of the island. These plant speices contribute to sediment trapping and promote the movement of Kent Island westward, further diminishing the channel.

Dredging the Bolinas Channel, if done in isolation, would not be a long lasting solution as the geomorphology of the channel is determined by the hydrological conditions of the drainage area. As previously noted, in the upper reaches of the drainage, volume has been diminished by the build up in elevation of higher mudflat and tidal marsh, and at the lower reaches, by the increased accumulation of littoral sediment from the ocean. An engineered solution — dredging a large area between Kent Island and Pine Gulch Creek or dredging the entire channel — would increase the drainage volume and ebb tidal scour; however, there is already concern about erosion under the houses and docks along the lower Bolinas Channel. A more conservative approach is outlined in the Locally Preferred Plan.

First, watershed measures and floodplain restoration on Pine Gulch Creek will reduce sediment availability and deposition and minimize the growth of the delta. Second, sediment removal from the

delta will provide for increased wind fetch and wind-wave erosion power (preventing the expansion and perhaps reducing the area of tidal marsh between the delta and Kent Island). Third, as noted in the Locally Preferred Plan, as part of the analyses for sediment removal at the Pine Gulch Creek Delta, the EIS/EIR will also examine the possibility of hydrologically connecting the excavated area of the delta and the upper reach of Bolinas Channel. The Working Group does not recommend excavating Bolinas Channel itself (nor rerouting Pine Gulch Creek to the south to connect to the channel), but the excavated area may provide a tidal head that may scour and deepen the channel. Fourth, the Working Group recommends restoring Kent Island to a dynamic flood shoal island from its current anchored state; this may provide additional hydrological benefits to the lower channel area. A wider, deeper channel would provide potential eelgrass habitat and protect Kent Island from humans and predators.

Subtidal shallows and fish habitat?

Analyses in the PWA Report (2006) indicate that humans will have caused a 1.2 million cubic yard reduction in tidal prism and a shift of habitats from subtidal and low intertidal mudflat to higher intertidal mudflat and tidal marsh. The report also notes that species abundance and diversity in the lagoon will change with these shifts; for example, one-third of the 99 invertebrates listed as occurring in the lagoon are associated with subtidal and frequently submerged mudflat areas and are expected to experience declines as their habitat areas decrease (PWA Report 2006). Similarly, decreases in deeper water habitat will reduce foraging habitat for two feeding guilds of diving birds (fish-eating and benthos-feeders) and most of the 38 species of fish known to occur in the lagoon (PWA Report 2006).

The Working Group recommends excavating sediment from the Pine Gulch Creek Delta that may help to restore subtidal and lower elevation mudflat habitats. The sediment removal at this location also has other benefits (see discussion above). However, wide spread sediment removal to create subtidal habitat in other locations is not supported by the Working Group for several reasons: 1) the 1984 T-Sheet shows that the lagoon did not have subtidal shallows in the north basin or other areas, and 2) increased rate of projected sea level rise is expected to substantially lengthen the time existing shallows remain extant.

Why not remove the 1.2 million cubic yards of sediment accumulation attributable to humans?

The 1.2 million cubic yards is more precisely a ball-park estimate of how much tidal prism will be lost from 1854 to 2050 that is attributable to humans. This includes direct fill from roadways,

Seadrift housing, and the artificial lagoon as well as the increased alluvial sediment availability and deposition from changes in the watershed and floodplains. The recommendations of the Locally Preferred Plan in the watershed and floodplains are focused on restoring natural hydrologic functions and minimizing the amount of alluvial sediments deposited in the lagoon. The Working Group also recommends sediment removal from Pine Gulch Creek Delta — a delta that was not on the 1854 T-Sheets — to increase tidal prism, create subtidal shallows and lower mudflat habitat, potentially increase wind-wave erosion action (keeping mudflat elevations low), and potentially create tidal head and scour if hydrologically connected to Bolinas Channel. Additional modeling and evaluation of the ecological costs and benefits will determine the area, depth, gradient, and volume of the excavated area but it would in all likelihood provide less than 10% of the estimated 1.2 million cubic yards of tidal prism loss attributable to humans. An argument could be made to remove more of the unnatural sediment — much of it deposited before the turn of the century after wide spread logging and other land use changes. However, given the substantial cost, question of sustainability (particularly if dredging the channels or near the mouth or central area of the lagoon), and potential for ecological disturbance on one hand and the ameliorating affects of increased sea level rise and eventual tectonic subsidence, the Working Group does not recommend a large scale project to deepen the lagoon.

Tree removal and fish habitat?

The Working Group has made two recommendations addressing tree and woody debris in the creeks and lagoon. The Working Group recommends leaving downed trees and fallen woody debris in the creeks as they provide important components of salmonid (and other fish) habitat. The downed trees and woody debris also will promote the creeks natural free movement. For example, current flood control practices that remove this material act to keep Pine Gulch Creek in it current artificially constrained channel. Downed trees and woody debris in the creek act as small dams — flood waters would spread out over the banks and heavy sediments would be deposited on upland areas rather than being pushed into the lagoon. A new creek channel may also develop, which would be beneficial in distributing sediments on additional upland areas in future storm events. Leaving trees and woody debris would require an evaluation as to the impacts on flooding of roadways, farm land, and houses.

The second Working Group recommendation concerns tree removal of large, primarily non native (eucalyptus) trees on the perimeter of the lagoon. The Working Group recommends that these fallen trees could act to capture sediment, particularly if they were to fall in the channels. Several

comment letters pointed out those fallen trees also provide fish habitat in lagoons. Additional investigation into the ecological costs and benefits of large tree removal from the lagoon is recommended and could be evaluated on a case by case basis.

What is the role of the Corps and who makes the final decisions?

The Corps is the lead federal agency in the Bolinas Lagoon Ecosystem Restoration Project with the State Coastal Conservancy. Marin County Open Space District (MCOSD) is the local sponsor. The Superintendent of the Gulf of the Farallones National Marine Sanctuary (GFNMS) has a seat on the Executive Committee, and has taken the lead in developing the Locally Preferred Plan through the Sanctuary Advisory Council. NOAA will participate as a cooperating agency in revising the Corps' Bolinas Lagoon Feasibility Study and Draft EIS/EIR. Although the Corps will continue to be the lead federal agency on this project, the Coastal Conservancy, NOAA, and MCOSD will have a far greater role in framing and overseeing the revisions of the Feasibility Study and Draft EIS/EIR as compared to the previous draft. In the Feasibility Study and EIS/EIR process, the Corps is required to develop a "National Plan" to compare with the Locally Preferred Plan — in most cases, the Locally Preferred Plan is the preferred alternative. There will be substantial public participation and opportunity to comment on the Bolinas Lagoon Feasibility Study and Draft EIS/EIR.

Many of the restoration actions outlined in the Locally Preferred Plan will be carried out by MCOSD, NOAA, or other resource agencies that have jurisdiction or responsibility for specific projects. The final decision on implementing individual projects will be made jointly among all partners, but principally by the agency or agencies directly responsible for conducting the specific activity.

Easkoot Creek floodplain function and delta removal?

Easkoot Creek floodplain has been impacted in several ways. Historically, during very large storm events, the creek would push through the dunes and flow into the ocean. The creek has also been constrained at various bridges, houses and commercial buildings, and riparian habitat lost as the creek turns north through the park and enters Bolinas Lagoon. The Working Group recommends that the County of Marin (Marin County Flood Control District) and the Golden Gate National Recreation Area investigate the use of GGNRA Stinson Beach lands to improve floodplain function for Easkoot Creek. The Working Group also recommends an educational campaign and continued enforcement of creek set back regulations so that floodplain functions along Easkoot Creek are not further impinged by

development. The Working Group does not recommend sediment removal at the confluence of the creek with the lagoon — there is no delta build up (i.e., conversion of wetlands to uplands) but a tidal brackish marsh.

Why not create sediment traps at the confluence of the creeks and the lagoon?

Objective 1 is to "Restore natural sediment transport and ecological functions of Bolinas Lagoon by ameliorating the negative effects of human induced changes." The approach of this project is to undertake watershed measures to reduce sediment availability and restore natural floodplain functions to reduce sediment deposition in the lagoon. Use of sediment traps — other than those required to maintain culvert function by Caltrans — requires repeated maintenance; keeps creeks in their current channelized condition; may adversely impact salmonid and California red-legged frog habitat; and are largely ineffective if not substantial in size and not excavated after each large storm event.

How are the recommendations prioritized?

The recommendations in this document are not prioritized. Many of the recommendations will require additional analyses and modeling to determine their efficacy, ecological costs and benefits, and long-term effectiveness.

Eelgrass?

Currently it is uncertain why eelgrass has largely disappeared from Bolinas Lagoon. The Working Group recommends further investigation is needed to determine if there is habitat suitable for eelgrass in the lagoon. The largest recent eelgrass beds were found in Bolinas Channel and there are small remnant patches. The excavated area from Pine Gulch Creek Delta may provide a tidal head and increased circulation through the Bolinas Channel, which may provide suitable habitat for eelgrass re-colonization.

Why not create acclimation basins for salmonids at the mouths of creeks?

Acclimation basins were not natural features in the lagoon and are not required habitat to sustain salmonid populations in the lagoon's tributaries.

II. Project History

The 1996 Bolinas Lagoon Management Update described the lagoon as having lost significant tidal prism since 1968. Based on the results of the 1996 Management Update, MCOSD recommended that additional studies be conducted to corroborate this finding and determine the future magnitude of tidal prism loss. A reconnaissance study conducted by the United States Army Corps of Engineers (the Corps) in 1997 concluded that corrective action to reduce the loss of tidal prism was a matter of national interest. The Corps, the Coastal Conservancy, and MCOSD, prepared a Feasibility Study in 1998 to develop a plan to restore the lagoon. The Corps released its Draft Feasibility Report and Draft EIS/EIR for the Bolinas Lagoon Ecosystem Restoration Project in 2002. Throughout several phases, the study called for dredging approximately 1.4 million cubic yards of sediment from the lagoon. Public comments challenged the conclusions of the study, citing the need for a clear, scientifically sound description of how the lagoon would evolve if no action was taken. The Marin County Board of Supervisors supported this recommendation. MCOSD hired Phil Williams and Associates to conduct a rigorous investigation of the recent history of Bolinas Lagoon and provide a 50-year projection of the hydrological and ecological evolution of the lagoon. As part of this effort, MCOSD assembled two panels of independent scientists with expertise in a variety of relevant disciplines to assist the consultant team in identifying data gaps and collecting and analyzing new data and provided peer review of the reports. The consulting team completed a series of five reports documenting its findings in July 2006. The reports presented numerous key findings on the past, current and future evolution of Bolinas Lagoon and were accepted by MCOSD as the no action alternative for the 2002 Draft Feasibility Report and Draft EIS/EIR. The complete document can be obtained from the Marin County Open Space District website (http://www.co.marin.ca.us/pos/MCOSD/Bolinas-Lagoon-Updates.asp).

III. Jurisdictional Setting & Responsible Agencies

Jurisdictional Setting

Historically, the tidelands of Bolinas Lagoon had been under the jurisdiction of the State of California. In January 1956, the Bolinas Harbor District signed a 10-year lease to manage the lagoon's tidelands. The Harbor District, a public body, was interested in developing a ten-million-dollar marina in Bolinas Lagoon. Prior to releasing the plan for the marina, the Harbor District implemented and/or supported several scientific and technical investigations of Bolinas Lagoon and its watershed (Gustafson 1968; IEC 1968). In 1966, the Harbor District presented a plan for an extensive marina to accommodate 1,600 boats. Kent Island was identified as the site for dredged material placement and marina infrastructure. This was problematic considering that a portion of Kent Island was owned by Audubon Canyon Ranch. Audubon Canyon Ranch and the Nature Conservancy pooled their resources and purchased the remainder of Kent Island from private owners. Because Kent Island was identified in the Harbor District's plans as the site for dredged spoils and infrastructure for the marina, the Harbor District could not use the site for these purposes. In 1967, Audubon Canyon Ranch and the Nature Conservancy donated lands in Bolinas Lagoon, including Kent Island, to Marin County with the caveat that the lands would be maintained as a nature preserve. The local population voted to dissolve the Harbor District in 1969 for economic reasons.

The California State Lands Commission granted all lands, salt marsh, tidelands, submerged lands, swamp, and overflow lands in Bolinas Lagoon situated within the boundaries previously held by the Bolinas Harbor District to Marin County in 1969. The law transferring the tidelands required the County to submit to the State a plan for the use and protection of Bolinas Lagoon. Since 1972, Marin County has provided management plans for Bolinas Lagoon and will continue to do so in the future.

As a precursor to the Bolinas Lagoon Technical Advisory Council (BLTAC) the Marin Conservation League, in 1971, formed a committee focused on the ecology of Bolinas Lagoon. Then in 1974, recognizing the need for technical and citizen input into the management of Bolinas Lagoon, the County established BLTAC. In 1977 Bolinas Lagoon was designated a Marin County Nature Preserve, to be managed by the Marin County Parks Department. In 1988, Marin County transferred the management of the Bolinas Lagoon Open Space Preserve to the Marin County Open Space District (MCOSD).

In 1981, Bolinas Lagoon was included within the federally designated Gulf of the Farallones National Marine Sanctuary (GFNMS) by the National Oceanic and Atmospheric Administration. GFNMS has jurisdictional and permit authority over the waters and seabed of the lagoon up to the mean high tide.

Numerous other, state, federal and local agencies have jurisdictional, planning or regulatory oversight of the lagoon and its watershed. Bolinas Lagoon adjoins Pt. Reyes National Seashore, Golden Gate National Recreation Area, Mount Tamalpais State Park, and Audubon Canyon Ranch.

Responsible Agencies

National Oceanic and Atmospheric Administration (NOAA); Gulf of the Farallones National Marine Sanctuary (GFNMS)

NOAA provides comprehensive and coordinated conservation and management to the 1281 square miles of near-shore and offshore waters of the eastern Pacific and the submerged lands there under designated as the Gulf of the Farallones National Marine Sanctuary (GFNMS). NOAA designated the GFNMS in 1981 under the authority of the National Marine Sanctuaries Act (16 U.S.C. 1431 *et seq*.). The GFNMS, which includes Bolinas Lagoon up to the mean high tide line, was established to protect and preserve the distinctive conservation, recreational, ecological, and aesthetic qualities of the ecosystems and habitats included within.

With certain exceptions, GFNMS regulations (15 CFR Part 922) prohibit the following activities within the Sanctuary:

- Discharges or deposits of materials;
- Dredging or otherwise altering the seabed;
- Using motorized personal watercraft;
- Constructing any structure other than a navigational aid (this prohibition applies to installation of moorings in the Sanctuary).

NOAA has recently proposed new regulations that would prohibit anchoring in sea grass beds in certain zones in Tomales Bay, releasing introduced species, and deserting a vessel aground, at anchor, or adrift in the Sanctuary (71 FR 59338; October 6, 2006).

National Oceanic and Atmospheric Administration (NOAA); National Marine Fisheries Service (NMFS)

The National Marine Fisheries Service is primarily concerned with the preservation and management of marine, estuarine, and anadromous resources. The NMFS functions in an advisory role (similar to USFWS), reviewing permit applications submitted for the Corps and conducting Section 7 consultations under the Endangered Species Act (ESA) as necessary. The Service has federal agents in the San Francisco Bay area to investigate violations of the GFNMS, ESA and Marine Mammal Protection Act and to issue citations or press charges in federal court.

National Park Service (NPS); Point Reyes National Seashore (PRNS); Golden Gate National Recreation Area (GGNRA)

The Point Reyes National Seashore was established in 1962 and ten years later, the Golden Gate National Recreation Area (GGNRA) was established. A current administrative agreement provides that the superintendent of Point Reyes has management authority over the entire National Seashore and Olema Valley portion of GGNRA north of the Fairfax-Bolinas Road, Point Reyes was granted concurrent jurisdiction enabling their rangers to enforce local, state, and federal legislation and rules. The superintendent of GGNRA, with headquarters at Fort Mason, retains administrative and maintenance supervision over all NPS lands south of the Fairfax-Bolinas Road. Currently (July 2008), GGNRA and PRNS are updating their General Management Plans. The NPS requires permits for actions by other agencies on its lands.

U.S. Fish and Wildlife Service (USFWS)

The U.S. Fish and Wildlife Service is concerned with the management, conservation, and development of the nation's water, wildlife, fish, mineral, forest, and park and recreational resources. One of the principal goals of the service is to prevent piecemeal destruction of remaining wetland areas, recognizing that estuaries must serve both human and wildlife purposes. USFWS acts in an advisory role, reviewing and commenting on permit applications received by the Corps. Any action that requires a federal permit (such as dredging) that may affect listed or proposed species would require a Section 7 consultation under the ESA.

United States Army Corps of Engineers (the Corps)

The Army Corp of Engineers is a regulatory agency, issuing permits for obstructing, altering, and discharging into the waters of the United States on the basis of public benefit under Section 10 (River and Harbors Act of 1899) and under Section 404 of the Clean Water Act (See EPA).

Environmental Protection Agency (EPA)

Regulations issued under the Federal Water Pollution Control Act of 1972 (amended 1977) require all vessels with propulsion machinery to have the capacity to retain oily mixtures on board. A bucket or bailer is suitable as a portable means for collecting oily waste on recreational vessels for proper disposal. No person may intentionally drain oil or oily waste from any source into the bilge of any vessel. Discharges of oil or other hazardous substances are prohibited within 12 miles of the coast and within fisheries and marine preserves up to 200 miles from the coast under the Clean Water Act (40 CFR Part 110.6).

Section 404 of the Clean Water Act (CWA) regulates the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities).

United States Coast Guard

U.S. Coast Guard regulations prohibit dumping of plastic refuse and garbage mixed with plastic into any waters. The Coast Guard is responsible for law enforcement on federal waterways and for providing aids to navigation (e.g., channel markers, lights, etc.) as needed. They are required to review the Corps permits for the construction of piers or docks and issue permits for operations that involve the transfer of fuel and refueling of boats. Their main responsibility is with oil pollution and handling of hazardous substances and to oversee cleanup operations.

State Lands Commission (SLC)

Chapter 787 of the Laws of 1969 grants to Marin County all lands, salt marsh, tidelands, submerged lands, swamp, and overflowed lands in Bolinas Lagoon situated and lying within the boundaries previously held by the Bolinas Harbor District. The terms of the grant required the County to prepare and submit a plan for improvement, restoration, preservation, and/or maintenance by the county without expense to the state. In addition, the lands must be used for purposes in which there is a general statewide interest, such as public access and multiple uses of resources.

California Coastal Commission (CCC)

The CCC has the primary responsibility for implementation of the California Coastal Act and has been designated by the State Coastal Zone Planning and Management Agency for any and all purposes and may exercise any and all powers set forth in the Federal Coastal Zone Management Act of 1972 (16 U.S.C. §1451, et seq.) and any amendments thereto or other federal laws that relate to the planning or management of the coastal zone. The California Coastal Act mandates the protection and restoration of coastal waters. The CCC certifies local coastal programs and approves coastal development permits, energy projects, and federal projects within the Coastal Zone in accordance with water quality policies in the California Coastal Act. The CCC's federal (CZMA) authority includes review of all federal agency activities and authorizations in or affecting the coastal zone, including, but not limited to, management plans. The CCC protects water quality in its function of permit authority over development that generates runoff, creates spills, or otherwise affects water quality. The CCC also implements educational and technical assistance programs and coordinates with other agencies to address land-use and development activities that may generate polluted runoff.

The CCC, in partnership with coastal cities and counties, plans and regulates the use of land and water in the coastal zone. Bolinas Lagoon is part of the Coastal Zone and falls under Marin County's certified Local Coastal Program (LCP). The primary goals of the LCP is to ensure that the local government's land use plans, zoning ordinances, zoning district maps, and implemented actions meet the requirements of, and implement the provisions and polices of the California Coastal Act at the local level. The CCC retains permanent coastal permit jurisdiction over development proposed on tidelands, submerged lands, and public trust lands, and the CCC also acts on appeals from certain local government coastal permit decisions. The CCC reviews and approves any amendments to previously certified LCPs.

California Coastal Conservancy

The Conservancy Act authorizes the California Coastal Conservancy to award grants to state and local public agencies for the purpose of enhancing coastal areas which have suffered a loss of natural and scenic values. The thrust of the Conservancy's involvement in wetlands is to assist local governments in the rehabilitation, enhancement, and management of wetlands that are to be owned and managed locally. These activities take place under one or more Conservancy programs: resource enhancement, restoration, site preservation, and resource protection zones. Although several other state and federal agencies are involved with wetlands, they are generally interested in the acquisition of those resource areas that are the most pristine and productive.

State Water Resources Control Board (California Water Board) and Regional Water Quality Control Board (RWQCB)

The Porter-Cologne Water Quality Act (Cal. Water Code, Sections 13000 et seq.) was enacted in 1969 to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use of the benefit of present and future generations. The Act established the State Water Resources Control Board (the California Water Board) and nine Regional Water Quality Control Boards as the principal State agencies with the responsibility for protecting water quality in California. Under the Act, the Water Board has the ultimate authority over State water rights and water quality policy, and the regional boards oversee water quality on a day-to-day basis at the regional level by determining the beneficial uses for all water-bodies within their jurisdiction, establishing and enforcing water quality standards for surface and groundwater, and taking actions needed to maintain the standards by controlling point and non-point sources of pollution. The Porter Cologne Act and the San Francisco Bay Basin Plan prohibit the discharge of raw sewage or any waste that fails to meet waste discharge requirements into Bolinas Lagoon. The RWQCB has the authority to investigate and regulate discharges of waste into Bolinas Lagoon. State discharge requirements for marine areas are the same as federal requirements.

California Department of Fish and Game (CDFG)

The California Department of Fish and Game is responsible for conserving, protecting, and managing California's fish, wildlife, and native plant resources. Any person, state or local governmental agency, or public utility to notify CDFG before beginning an activity that will substantially modify a river, stream, or lake. CDFG has historically has a more limited jurisdiction than the Corps, focusing specifically on lakes, major, tidal sloughs, rivers, and streams, where streams are defined as "…a body of water that flows at least periodically or intermittently through a bed or channel having banks…" CDFG also typically includes riparian areas adjacent to rivers and streams with ins jurisdiction. If CDFG determines that the activity could substantially adversely affect an existing fish and wildlife resource, a Lake or a Streambed Alteration Agreement is required. Because this project may affect creeks and riparian areas adjacent to creeks, a Streambed Alternation Agreement could be required for creeks on state, county, and private lands. If so, an application would be filed subsequent to production of the final environmental document.

CDFG was established to administer and enforce the Fish and Game Code. The Department is empowered to review EIR's on development projects and recommend conditions for any activity proposed within inland waterways, and must be notified prior to any such action. Department authority is generally restricted to below the mean high tidal level in estuarine waters but may overlap the jurisdiction of other agencies, including the State Lands Commission and the Corps. The Commission establishes the regulations for sport fishing and the CDFG issues permits for the commercial harvest of fish and invertebrates, which enables them to manage aquatic resources.

Department of Transportation (Caltrans)

Caltrans is responsible for maintaining State Highway 1 along the perimeter of Bolinas Lagoon. Current maintenance consists of thin blanket resurfacing, rehabilitative maintenance, and an occasional drainage project.

Marin County Open Space District (MCOSD)

The MCOSD is responsible for managing Bolinas Lagoon. When the State Lands Commission granted the lagoon to the County, the Marin County Parks and Recreation Department (which preceded the MCOSD as the lagoon's managing entity) developed the Bolinas Lagoon Plan. In 1988 management responsibility for the lagoon was transferred to MCOSD, and the Bolinas Lagoon Nature Preserve became the Bolinas Lagoon Open Space Preserve.

Marin County Community Development Agency

The County Community Development Agency has responsibility for the preparation and implementation of a General Plan for the control of land use and development in the unincorporated areas of the County. The Marin Countywide Plan, adopted in 1973, designates Bolinas Lagoon as a Conservation Zone within the Coastal Recreation Corridor. This zone allows only limited development under strict controls. The agency reviews actions under the Tidal Waterways Ordinance to ensure that proposed actions will not cause severe or irreparable damage to the environment, with the burden of proof falling on the developer or agency wishing to take action. In addition, the criterion of finding of need applies to conservation zones. This means that the applicant must demonstrate that the proposed use requires a site within the Conservation Zone and that alternate sites outside the zone cannot be found. Additional requirements for approval include a specific finding of safety, water quality protection, and demonstration that the proposed action will not damage the land at the water's edge, fish and aquatic habitats, navigation, or public use of the water.

Marin County Public Works Department

The Public Works Department has responsibility for construction and maintenance of all public works, and includes divisions relating to roads, building and inspection, flood control, and engineering services.

IV. Key Bolinas Lagoon Habitat Definitions

(Excerpts of the PWA Report and the 2000 Draft Feasibility Study)

Subtidal: The subtidal or open water portions occur below MLLW. This habitat is strongly influenced by its connection with the Pacific Ocean. Daily tidal action introduces a substantial volume of ocean water. This habitat remains submerged during a typical spring or neap tide.

Subtidal Channels: Scour by tidal currents, which is largely determined by tidal prism, maintains the depth, width and cross-sectional area of these channels.

Subtidal Shallows: Subtidal shallows are confined to two relatively small areas at the deepest areas in the North Basin and South Arm.

Intertidal Mudflats: This zone is found between MLLW and approximately one foot above LMSL. Intertidal habitat is most commonly defined as the area between MLLW and MHW. This area experiences wetting and drying during a one-month period, with typical spring and neap tides.

Frequently Submerged Mudflats: Generally occur between MLLW to approximately 0.5 feet below LMSL.

Frequently Exposed Mudflats: Generally occur between 0.5 feet below LMSL and approximately one foot above LMSL.

Salt Marsh: Marsh habitats occur at relatively high elevations within the tidal frame, usually higher than one foot above the LMSL up to five feet above LMSL.

Low-elevation salt marsh: Typically occurs from 0.5 ft above LMSL to 2.5 ft above LMSL.

Mid-elevation salt marsh: Typically occurs between 2.5 ft and 3.5 ft above LMSL.

High-elevation salt marsh: Typically occurs from 3.5 feet to five feet above LMSL.

Brackish Marsh/Riparian Interface: Brackish marsh is found in transitional areas between coastal salt marsh and freshwater marsh or riparian habitats. This area consists of fresh and salt water.

Upland: The area that remains above the water line at high tide during a typical spring tide.

Fluvial Delta/Riparian: Riparian habitats include areas along the deltas of several small creeks and streams that convey water from the surrounding watershed.

Flood Tide Island/Coastal Sand Dune: Flood tide shoals dry out during low tide, and wind-blown sand shapes the beach and dune

V. Commonly Used Acronyms

BLTAC	Bolinas Lagoon Technical Advisory Committee
CCC	California Coastal Commission
Cal-IPC	California Invasive Plant Council
CDFG	California Department of Fish and Game
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
GFNMS	Gulf of the Farallones National Marine Sanctuary
GGNRA	Golden Gate National Recreation Area
ISP	Invasive Spartina Project
LPP	Locally Preferred Plan
LMSL	Local Mean Sea Level
MCC	Marin Conservation Corps
MCOSD	Marin County Open Space District
MMWD	Marin Municipal Water District
MHW	Mean High Water
MLLW	Mean Lower Low Water
NER	National Ecosystem Restoration
NMFS	National Marine Fisheries Service
PRBO	PRBO Conservation Science
PRNS	Point Reyes National Seashore
SBCWD	Stinson Beach County Water District
SFEI	San Francisco Estuary Institute
SLC	State Lands Commission
USCG	United States Coast Guard
USFWS	United States Fish & Wildlife Service
WMA	Weed Management Area (Marin-Sonoma)

VI. Glossary

Adaptive management: An iterative process used by resource managers to implement policy decisions based on monitoring results. This technique applies scientific principles and methods to improve management from experience and as new findings and social changes demand.

Alluvial: Material composed of sand, silt or clay, deposited on land by streams.

Anthropogenic: Effects or processes that are derived from human activities, as opposed to natural effects or processes, that occurs in the environment without human influence.

Bathymetry: Measurement of water depth.

Best Management Practices (BMPs): A practice or combination of practices that are determined to be the most effective and practicable (including technological, economic and institutional considerations) means of controlling the issue at hand. A management practice for reducing the amount of pollution and/or sediment entering a water body. The term originated from the rules and regulations developed pursuant to the federal Clean Water Act (40 CFR 130).

Biodiversity: The variety of life and its processes. Biodiversity includes the diversity of landscapes, communities, and populations (genetic variation).

Biota: All living organisms that exist in a region.

Brackish: Mixture of fresh and salt water (0.5-18 parts per thousand). Ocean water is typically 35 ppt, freshwater is less than 0.5 ppt).

California Environmental Quality Act (**CEQA**): State regulations require government agencies and other parties to consider potential environmental impacts of proposed actions.

Causeway (**Causeway bridge**): A causeway is a bridge between 36-40 feet wide, of various lengths. Causeways are built on concrete pilings on the same alignment as the existing roadway.

Channelization: Straightening and deepening of streams which forces directional water flow; can disturb fish and wildlife habitats, and aggravate flooding.

Culvert: A drainage conduit that crosses under a road or embankment.

Delta: An area formed by alluvial deposits of sand, silt, mud, and other particles at the mouth of a river.

Deposition: A natural process when rocks and sediment settle at the bottom of a river or creek.

Dredging: Removal of sediment from the estuary and ocean floor; includes subcutaneous dredging.

Easements: Areas that allow for unrestricted movement of biota by connecting protected wildlife regions to each other. These corridors are usually established by joint agreement between landowners and state or federal agencies and may be temporary or perpetual.

Ecosystem: A basic functional unit of nature comprising both organisms and their nonliving environment, intimately linked by a variety of biological, chemical, and physical processes a complex of interacting plants and animals with their physical surroundings. Ecosystems are isolated from each other by boundaries which confine and restrict the movement of energy and matter; for example, an ecosystem could be recognized at a watershed scale by designating an area of common drainage (i.e., topography determines movement of water).

Ecosystem management: A concept of natural resources management wherein human activities are considered within the context of economic, ecological, and social interactions within a defined area or region over both the short and long term. Its purpose is to meet human needs while maintaining the health, diversity, and productivity of ecosystems.

EIS/EIR: Environmental Impact Statements and Reports that are required by federal law (National Environmental Policy Act) and state law (California Environmental Quality Act) for major projects or legislative proposals that significantly affect the environment. EIS (federal) and EIR (state) facilitate decision making, describing the positive and negative affects of actions and prescribe alternative actions.

Ephemeral: A short-lived or transitory feature in nature.

Estuary: A coastal embayment of subtidal habitats (channel, tidal creeks) and adjacent intertidal (mudflat, salt marsh) wetlands that are semi-enclosed by land with open access to ocean waters that enter with the tides and freshwater steams.

Fill: Soil, sand, and debris deposited in aquatic areas, such as wetlands, to create dry land, usually for agricultural or commercial development purposes.

Floodplain: A flat area adjoining a stream or river that is constructed by the stream or river in the present climate and that receives over-bank flow at times of high discharge.

Flood tide: Incoming or rising tide; the period between low water and the succeeding high water.

Fluvial: Pertaining to rivers/creeks and their actions.

Grazing: Consumption by livestock and wildlife of range or pasture forage.

Habitat: Natural environment of a plant or animal; the locality where an organism may generally be found and where the essentials of its survival and reproduction are present.

Hydrology: Scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Indicator species: A species whose characteristics show the presence of specific environmental conditions and are representative of a certain habitat type or function.

Intertidal: The zone between mean lower low water and mean higher high water. Typically this zone undergoes periods of wetting and drying consistent with tidal propagation.

Definition of the National Invasive Species Council
Introduced species: Federal Executive Order 13112 defines "introduced species" as: "A species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health". Invasive species can be plants, animals, and other organisms (e.g., microbes).

Invertebrates: Small organisms, such as clams and worms that lack a spinal column. Many of these filter bottom sediments and water for food.

Lagoon: A shallow body of water, separated from the sea by a sand-spit. Lagoons may be continuously, occasionally or periodically connected to the ocean.

LiDAR (**Light Detection and Ranging**): An optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target.

Littoral drift: Movement of sediments along the shore of a coastal region or zone.

Littoral zone: A relatively narrow portion of a coast affected by wave energy and long shore currents

Maintenance dredging: Continued dredging of a constructed project over a period of time to remove recurring sediment.

Mean high water (**MHW**): Average height of all high tides.

Mean higher high water (**MHHW**): Average height of the higher of the daily high tides.

Mean low water (**MLW**): Average height of all low tides.

Mean lower low water (**MLLW**): Average height of the lower of the daily low tides.

Monitoring: A component of adaptive management in which information is collected to track change within an ecosystem.

Mudflat: Intertidal habitat that is usually covered with water during high tide and exposed during low tide, typically found below marsh habitats, and usually devoid of vegetation.

Native: Refers to those species originating naturally in a particular region.

National Environmental Policy Act (**NEPA**): Federal regulations that require government agencies to consider potential environmental impacts of proposed actions

Pollutant: A harmful chemical or waste material discharged into the environment. Persistent pollutants are those that do not degrade, causing potential long-term chronic toxicity to biotas.

Pollution: Impairment of land, air, or water quality by agricultural, domestic, or industrial waste to a degree having an adverse effect on beneficial uses or the facilities that serve such beneficial uses.

Performance measure indicators: A quantitative or qualitative variable with chosen parameters (e.g., riparian habitat, fish assemblage, stream channel condition) which can provide measurements of the current condition of a resource. Ecosystem indicators track the magnitude of stress, habitat characteristics, exposure to the stressor, or ecological response to exposure.

Progradation: Lateral expansion of a geomorphic feature.

Revetment: Structures placed on banks or cliffs in such a way as to absorb the energy of incoming water. They are usually built to preserve the existing uses of the shoreline and to protect the slope, as defense against erosion.

Runoff: Water from rain, melted snow, or agricultural or landscape irrigation that flows over the land.

Salinity: The number of grams of salt per thousand grams of sea water, usually expressed in parts per thousand. The salinity of ocean water is 32-35 ppt.

Sediment: Unconsolidated inorganic and/or organic mineral and rock particles, usually sand, silt or clay that are transported and deposited by flowing water.

Special status species: Federal and state classifications for plant and animal species that are either listed as threatened or endangered, are formally recognized candidates for a listing, or are declining to a point where they may be listed.

Suspended sediments: Volume of sediment transported in suspension by water; moves at a velocity slightly lower than that of water without many intermittent stages of deposition.

Tide: The alternating rise and fall of the ocean and bay surface that occurs twice a day, caused by the gravitational pull of the sun and moon upon the earth and by the rotation of the earth, moon, and sun.

Tidal prism: The volume of water that moves into or out of the system between low and high tide.

Tide range: The difference in the level between successive high and low tides.

Tidal scour: Erosion of sediments along a bank or bottom of a channel or creek, resulting from tides.

Tide gate: A water control structure that either allows water to flow freely when the tide sets in one direction, but which closes automatically and prevents the water from flowing in the other direction or a water control structure that restricts the total amount of water exchanged through a sliding mechanism that usually reduces the height of the tide level.

Watershed: An area of land with a characteristic drainage network that contributes surface or ground water to flow at a designated location; a drainage basin or a major subdivision of a drainage basin that catches precipitation such as rain and drains into an estuary, river, lake, or other body of water.

Definition of the Corps'

Wetlands: The term "wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Definition of Ramsar

Wetlands: The term "wetlands" means those "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters." Wetlands "may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands."

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VII. Figures

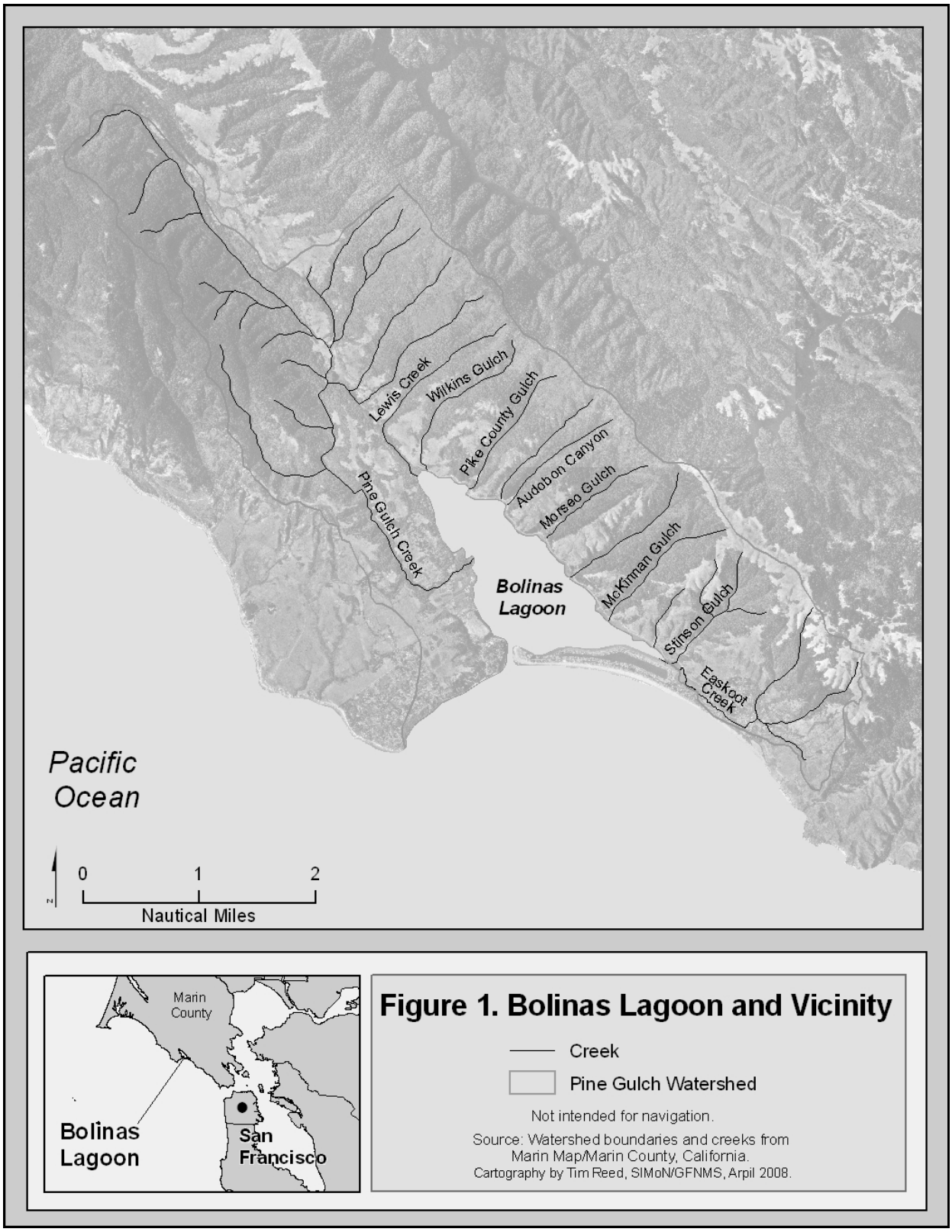

Figure 1. Bolinas Lagoon and vicinity.

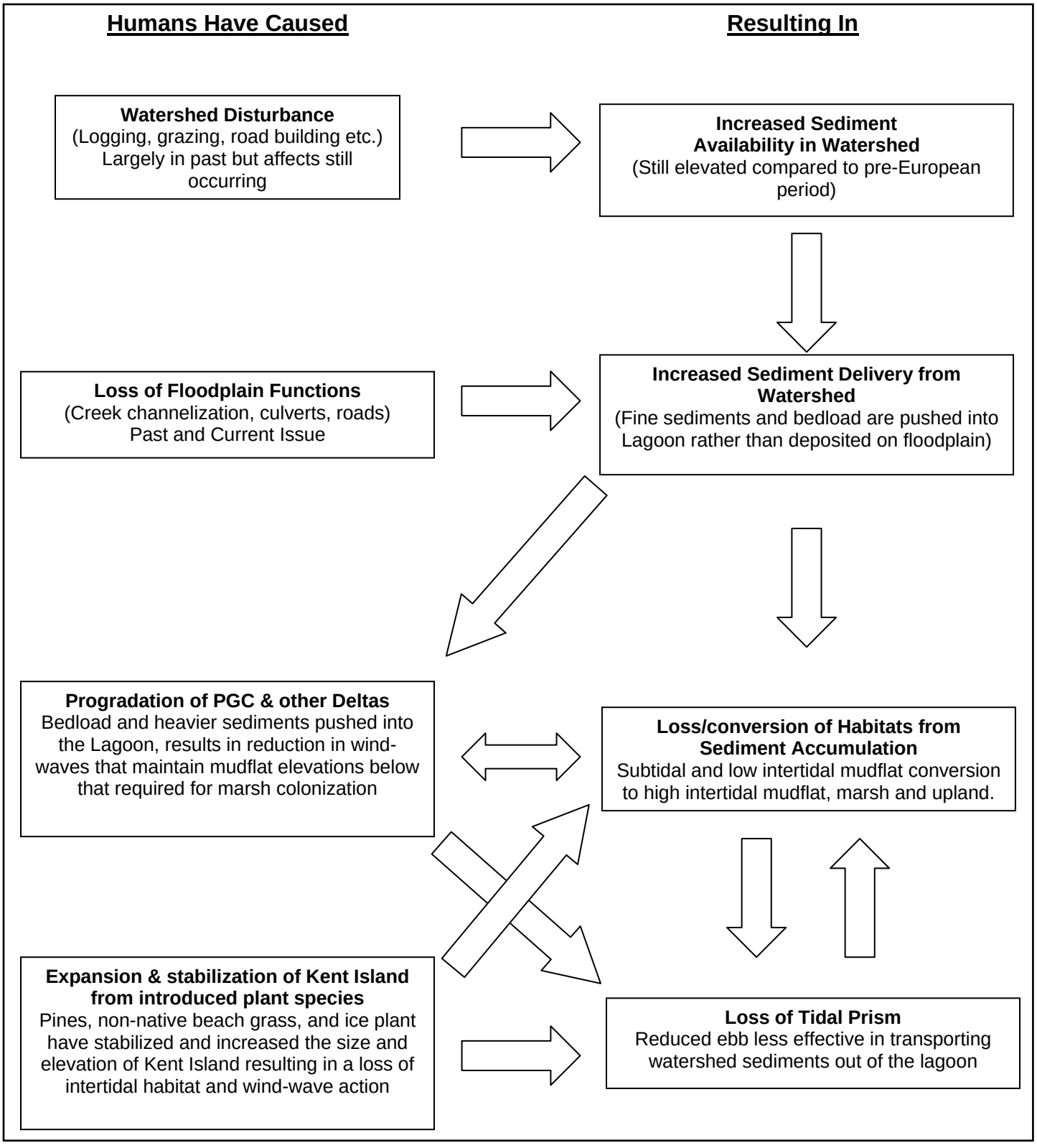

Figure 2. Flow chart of anthropogenic impacts to Bolinas Lagoon.

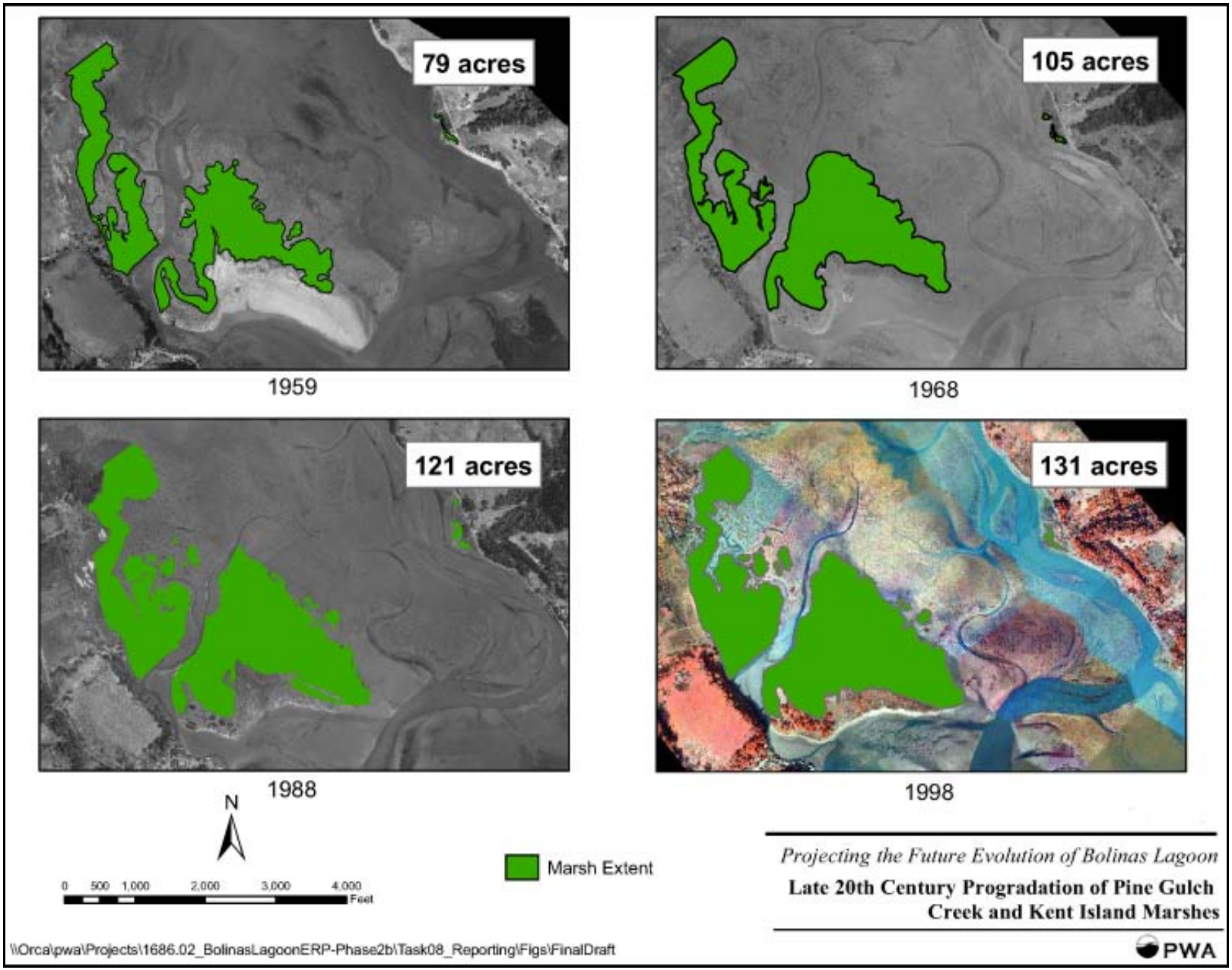

Figure 3. Late 20th century progradation of Pine Gulch Creek and Kent Island marshes *(excerpt of the PWA Report 2006).*

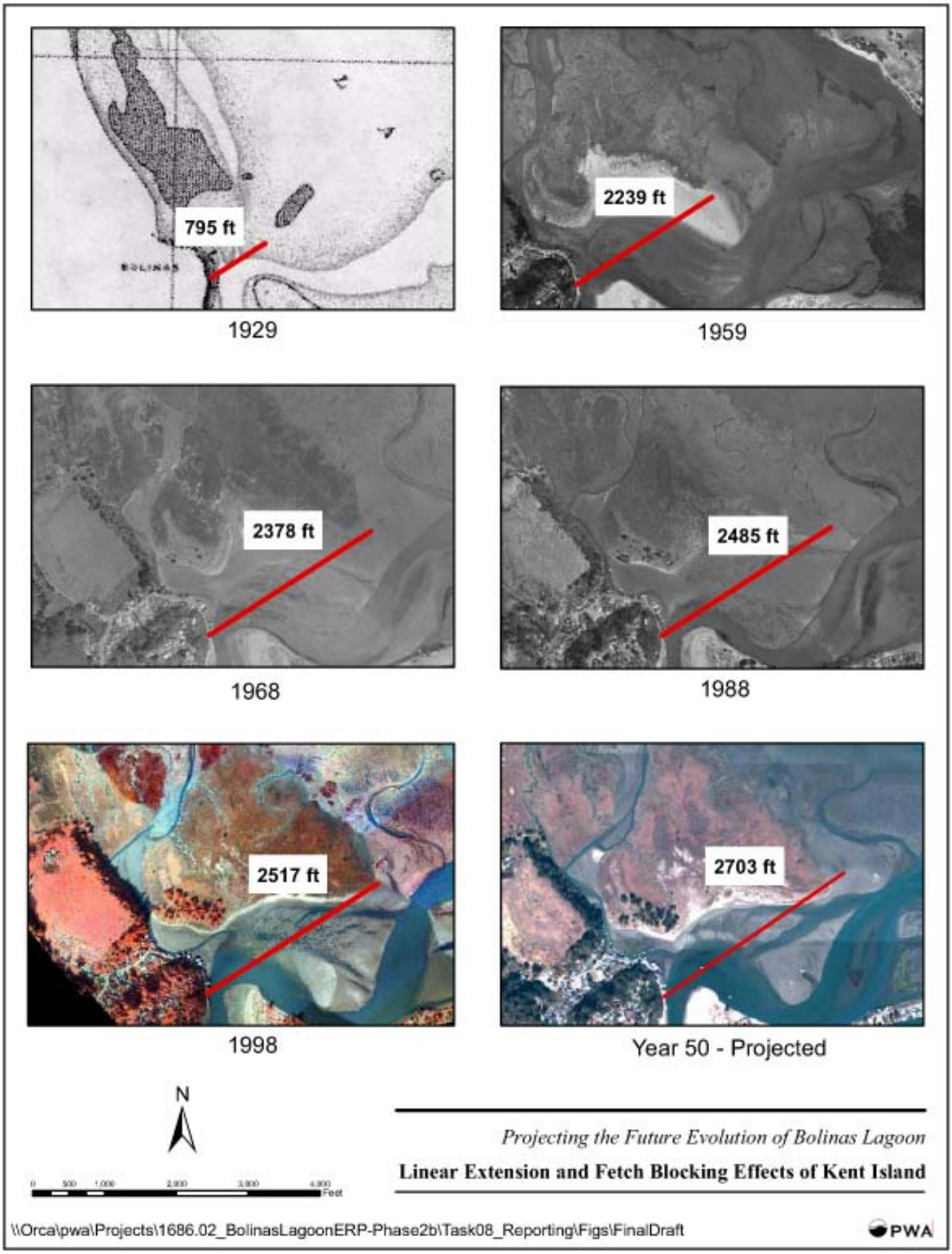

Figure 4. Linear extension and fetch blocking effects of Kent Island *(excerpt of the PWA Report 2006)*.

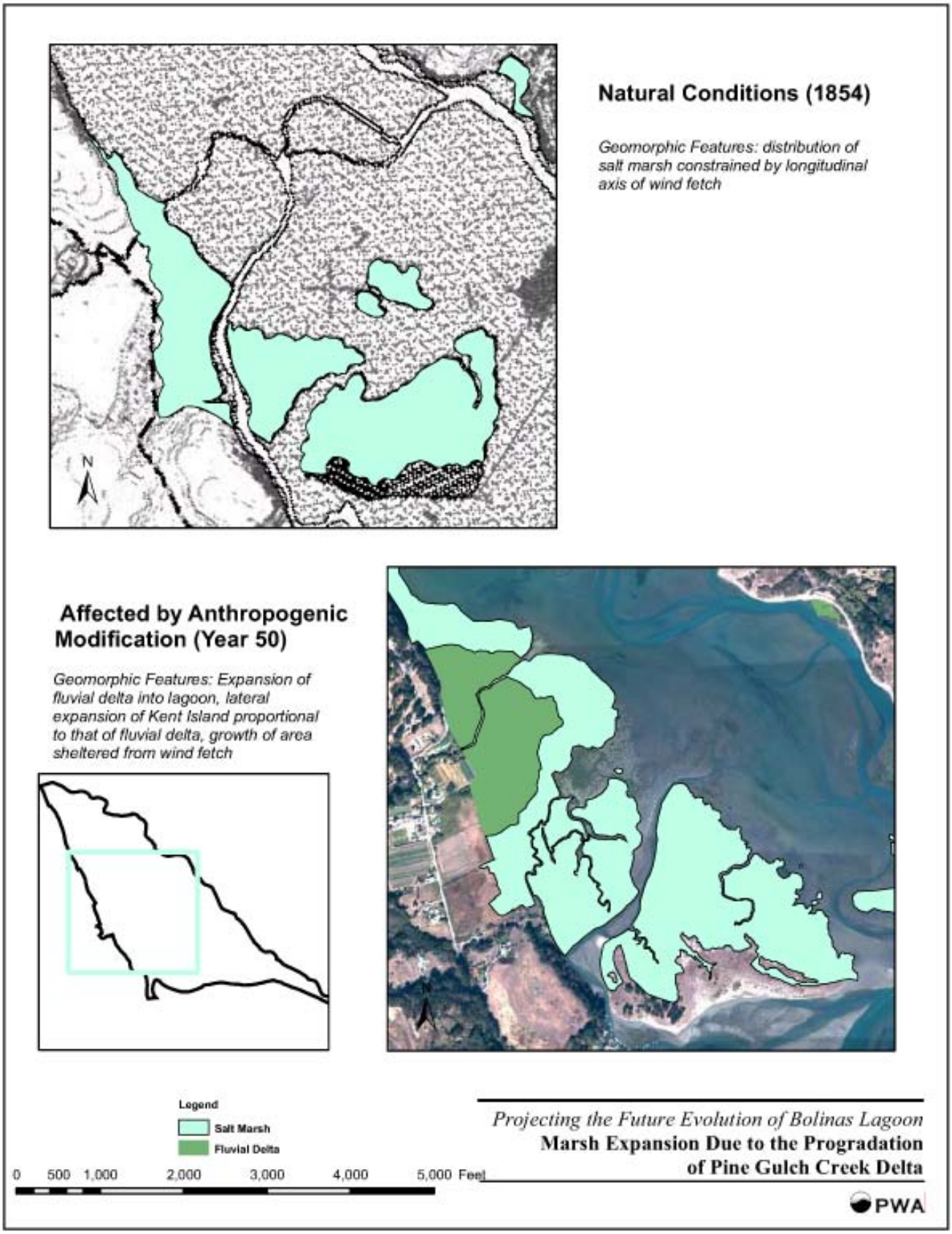

Figure 5. Marsh expansion due to the progradation of Pine Gulch Creek Delta *(excerpt of the PWA Report 2006)*.

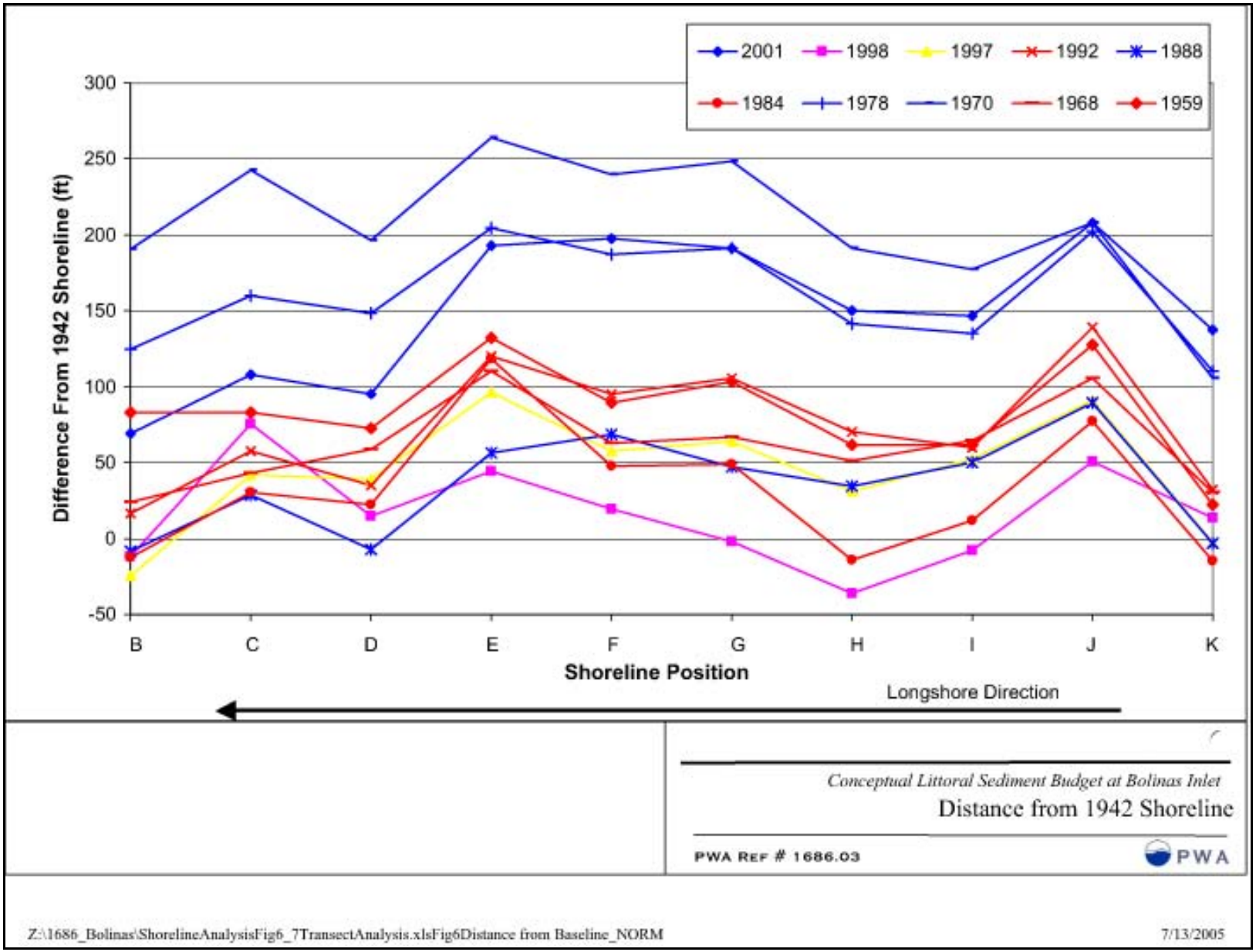

Figure 6. Distance from 1942 shoreline *(excerpt of the Conceptual Littoral Sediment Budget Report 2006).*

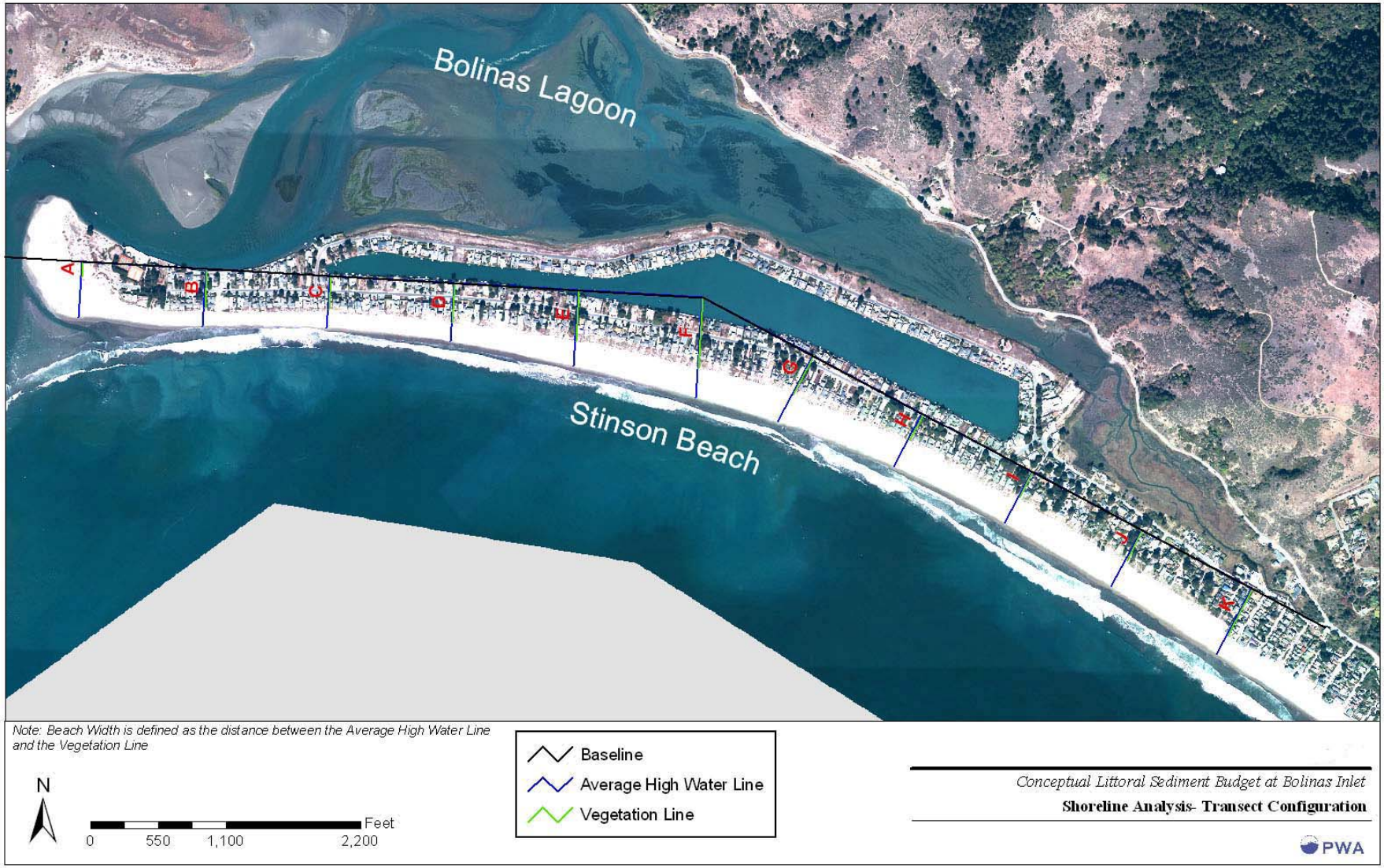

Figure 7. Shoreline analysis transect configuration *(excerpt of the Conceptual Littoral Sediment Budget Report 2006).*

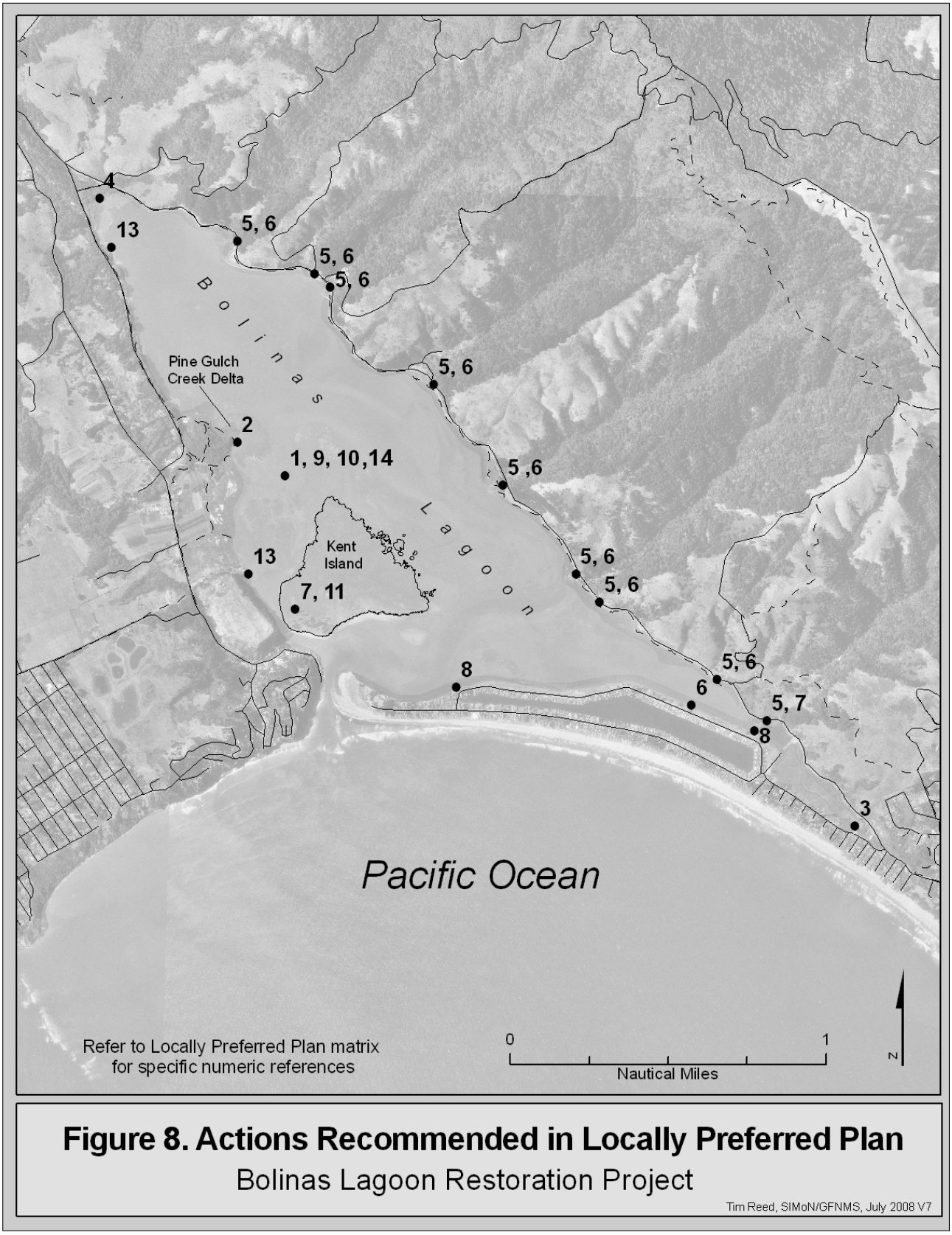

Figure 8. Actions recommended in the Locally Preferred Plan.

VIII. Tables

Table 1. Restoration recommendations in the Locally Preferred Plan.

#	Action	Lead or vested agency / organization
Objective 1: Restore natural sediment transport and ecological functions of Bolinas Lagoon by ameliorating the negative effects of human induced changes.		
Recommendations in the Locally Preferred Plan (LPP)		
Watershed		
1-LPP	Conduct a quantitative sediment source analysis of the Bolinas Lagoon watershed and seek remedies for problem areas.	**MCOSD**; GGNRA; PRNS; State Parks; Consultant
2-LPP Pine Gulch Creek		
2a-LPP	**Floodplain**: Reestablish the Pine Gulch Creek floodplain consistent with flood protection.	**MCOSD**; Property owners; the Corps; CCC; SLC; Contractor; Caltrans; CDFG; USFWS; GFNMS
2b-LPP	**Delta**: Remove a portion of the Pine Gulch Creek Delta. Delta removal must be sustainable and completed in conjunction with floodplain restoration activities.	**MCOSD**; Property owners; the Corps; CCC; SLC; Contractor; Caltrans; CDFG; USFWS; GFNMS
3-LPP Easkoot Creek		
3a-LPP	**Floodplain**: Investigate utilizing a portion of the GGNRA Stinson Beach parking lot as a seasonal floodplain for Easkoot Creek.	**GGNRA**; County of Marin
4-LPP Bolinas "Y"		
4a-LPP	**Floodplain**: Improve floodplain functions in the area of the Bolinas "Y," consistent with flood protection.	**MCOSD**; GGNRA; PRNS; the Corps; USFWS
4b-LPP	**Delta**: Remove a portion of the unnatural levels of sediment from north Bolinas Lagoon. Sediment removal must be sustainable and completed in conjunction with improving floodplain functions.	**MCOSD**; GFNMS; the Corps

#	Action	Lead or vested agency / organization
5-LPP East shore, including Stinson Gulch		
5a-LPP	**Floodplain**: Improve floodplain functions along the eastern shore of Bolinas Lagoon, consistent with flood protection.	**MCOSD**; Property owners; the Corps; CCC; SLC; Contractor; Caltrans; GGNRA; PRNS; CDFG; USFWS; GFNMS; ACR; SBCWD
5b-LPP	**Delta**: Prioritize removal of delta areas along the eastern shore of the lagoon. Delta removal must be sustainable and completed in coordination with improving floodplain functions.	**MCOSD**; ACR; GGNRA
6-LPP Habitat connectivity and transitional habitat		
6a-LPP	**Transitional habitat**: Improve transitional habitat along the east shore of Bolinas Lagoon.	**MCOSD**; ACR; GGNRA
6b-LPP	**Transitional habitat**: Improve transitional habitat along Dipsea Road	**MCOSD;** Seadrift Association
Kent Island		
7-LPP	Restore Kent Island as a dynamic flood shoal island.	**MCOSD**; ACR; MMWD; MCC; WMA; Cal-IPC
Seadrift Lagoon		
8-LPP	Investigate managing tidal exchange of Seadrift Lagoon to promote tidal circulation in Bolinas Lagoon.	**MCOSD**; Seadrift Association
Lagoon-wide		
9-LPP	Actively plan and manage for sea level rise at Bolinas Lagoon.	**GFNMS**; **MCOSD**; CalTrans; GGNRA; PRNS; ACR
Eelgrass		
10-LPP	Model suitable habitat for eelgrass and restore in appropriate areas.	**GFNMS**; NOAA Restoration; CDFG; the Corps
Objective 2: Identify and manage introduced species in the Bolinas Lagoon watershed.		
Kent Island		
11-LPP	Prioritize, remove and manage all introduced species on Kent Island.	**MCOSD**; ACR; MMWD; MCC; MCOSD; WMA; Cal-IPC

#	Action	Lead or vested agency / organization
Objective 3: Protect water quality by minimizing negative human impacts.		
Lagoon-wide		
12-LPP	Remove treated woody debris from Bolinas Lagoon.	**MCOSD**; GFNMS
13-LPP	Investigate and if feasible, remove dumps in Bolinas Lagoon.	**MCOSD**; GFNMS
14-LPP	Investigate water quality violations concerning septic and sewage systems throughout the Bolinas Lagoon watershed and remediate.	**MCOSD**; SBCWD

Table 2. Management recommendations for Bolinas Lagoon.

#	Action	Lead or vested interest
Objective 1: Restore natural sediment transport and ecological functions of Bolinas Lagoon by ameliorating the negative effects of human induced changes.		
Recommendation for Management Actions (MG)		
1-MG Best Management Practices (BMPs)		
1a-MG	Promote BMPs for farming, ranching, and residential areas, including the Bolinas Bluffs.	**MCCDA**; BCPUD
1b-MG	Work with stream-side property owners to assure protection of summer flow throughout the Bolinas Lagoon watershed (Pine Gulch Creek & Easkoot Creek).	**MCOSD**; County of Marin; GGNRA; Property owners
1c-MG	Protect floodplain functions of Easkoot Creek through the implementation of an education program.	**MCOSD**; County of Marin; GGNRA
1d-MG	Ensure BMPs for protecting native and controlling introduced species populations during restoration activities.	**GFNMS**; **MCOSD**
Lagoon-wide		
2-MG	Remove trees that fall into the lagoon & identify and remove potential tree hazards.	**MCOSD**; GFNMS
3-MG	Establish a long-term responsible wildlife viewing program.	**MCOSD**; **GFNMS**; PRNS
Bolinas mouth		
4-MG	Develop an emergency response plan in the event of a Bolinas mouth closure.	**MCOSD**; **GFNMS**; CCC; NMFS; CDFG; the Corps
Objective 2: Identify and manage introduced species in the Bolinas Lagoon watershed.		
Lagoon-wide		
5-MG	Immediately remove introduced cordgrass found in Bolinas Lagoon.	**GFNMS**; MCOSD; ISP
6-MG	Remove introduced plant and invertebrate species found in the Bolinas Lagoon watershed.	**MCOSD**; MMWD; MCC; WMA; PRNS; GGNRA; Cal-IPC; State Parks

#	Action	Lead or vested interest
Objective 3: Protect water quality by minimizing negative human impacts.		
Lagoon-wide		
7-MG	Develop a local oil spill response plan for Bolinas Lagoon.	**MCOSD**; GFNMS; USCG; CDFG
8-MG	Replace toxic-impregnated materials in Bolinas Lagoon.	**GFNMS**; MCOSD; CCC
9-MG	Promote environmentally sensitive use of facilities through an education program.	**MCOSD**; GGNRA; PRNS
South Lagoon		
10-MG	Identify toxins associated with the abandoned dredge and remove if feasible.	**GFNMS**

Table 3. Recommendations for adaptive management and monitoring.

#	Action	Lead or vested interest
Objective 1: Restore natural sediment transport and ecological functions of Bolinas Lagoon by ameliorating the negative effects of human induced changes.		
	Recommendation for Adaptive Management and Monitoring (AM)	
1-AM	Determine status & trends of fish, including salmonids, birds, and invertebrate populations and associated habitats.	**CDFG**; PRNS; GFNMS; MCOSD; Consultant
2-AM	Monitor wind-wave action in Bolinas Lagoon and determine if restoration recommendations in the Locally Preferred Plan have increased wind-wave action.	**MCOSD; GFNMS**
Objective 2: Identify and manage introduced species in the Bolinas Lagoon watershed.		
3-AM	Develop an Early Detection and Response Program for introduced species throughout the Bolinas Lagoon watershed.	**MCOSD**; MMWD; MCC; WMA; PRNS; GGNRA; Cal-IPC
4-AM	Monitor all introduced species on Kent Island. Monitor endangered plants on Kent Island.	**MCOSD**
Objective 3: Protect water quality by minimizing negative human impacts.		
5-AM	Maintain water quality monitoring efforts in Bolinas Lagoon.	**SBCWD**

Table 4. Species present in the Bolinas Lagoon watershed and on the Cal-IPC high priority list, 1-A.

Common name	**Scientific name**	**Location**	**Threats**
European beach grass	*Ammophila arenaria*	Windward side of Kent Is.	Captures sand, decreasing natural sand movement, and causing the dunes to increase in height
French broom	*Genista monspessulana*	Windward side of Kent Is.	Displaces native & beneficial plants
iceplant	*Carpobrotus edulis*	Windward side of Kent Is.	Excludes native dune mat vegetation; displaces two CNPS List 1B plant species: Wolf's evening primrose and pink sand verbena; and prevents natural movement of sand
cape ivy	*Delairea odorata*	Riparian areas along Pine Gulch, North Basin & small willow patches along the eastern shore	Cape ivy grows rapidly, dense vines overtop and smother out native shrubs, tree seedlings, & associated herbaceous plants, threat to integrity of coastal scrub and riparian vegetation
Himalayan blackberry	*Rubus discolor*	Riparian areas along Pine Gulch, North Basin & small willow patches along the eastern shore	Blackberries colonize disturbed areas and can dominate grasslands if uncontrolled. Blackberries are strong competitors which often displace natives. Additionally, blackberries are impenetrable thickets which can limit access to riparian areas by medium to large mammals and can block access for recreation
Jubata grass	*Cortaderia jubata*		Jubata grasses crowd out native plants, reduce diversity, create fire hazards with excessive buildup of dry leaves and stalks; Very sharp leaf blades

Table 5. Key habitats of Bolinas Lagoon.

Habitat Class	Major Habitat Type or Feature	Primary Subtype or Feature	Habitat or Feature Elements
Tidal	Subtidal (below MLLW)	Benthic sediments	sediment facies & patches, bathymetric depth intervals, etc.
		Subtidal water column	subtidal water depth intervals, water density layers, etc.
	Intertidal	Tidal flat (between MLLW & vegetated foreshore or MTL where vegetation is absent	intertidal channels, sediment facies, depth intervals, eel grass beds, bat ray hollows, shellfish beds, etc.
		Low marsh (MTL to MHW)	emergent plant species patches, tidal channels, etc.
		High marsh (MHW to MHHW)	emergent plant species patches, tidal channels, natural levees, pannes, etc.
		Backshore (MHHW to max. tide ht.)	tidal-upland ecotone, wrack, etc.
		Head-of-Tide (upstream limit of tidal influence on fluvial hydrology or salinity)	brackish water salinity, vertical water salinity strata, sediment facies
Fluvial	Channel pools	Benthic sediments	sediment facies & patches, bathymetric depth intervals, debris jams, etc.
		Water column	water depth intervals, submergent macrophytes, etc.
	Channel riffles & glides	Benthic sediments	sediment facies & patches, bathymetric depth intervals, debris jams, etc.
		Water column	water depth intervals, macrophytes, etc.
	Active floodplain (area above bankfull inundated approx. every 2.5 yrs)	Plain	interfluves, depressional wetlands, secondary channels, sediment splays, etc.
		Vegetation	trees, shrubs, forbs, bare ground, debris piles, etc.
	Flood-prone area (area on either side of channel with width 2x max. bankfull depth)	Plain	wetlands, terraces, paleo channels, etc.
		Vegetation	trees, shrubs, forbs, bare ground, debris piles, etc.
	Sediment sources	In-channel sources	bans, beds, confluences, etc.
		Hillside sources	debris shoots, landslides, storm drains, etc.

Table 6. Key physical indicators of Bolinas Lagoon.

Process	Indicators	Needed Data	Data Source	Frequency of Data Collection
Tidal exchange (flood & ebb of tidal water)	Tidal prism (volume of water between MHW & MLLW)	Surveys of subtidal bathymetry relative to MHW datum. ***Note***: subtidal aggradations or scour might be most sensitive indicator of spatial shifts in tidal energy or sediment transport, or change in sediment supply. Changes in volume of subtidal water would not be expected to affect tidal range.	Surveys along fixed transects across subtidal areas of major tidal channels & basins & into adjacent lower intertidal zone.	Annually (special surveys following major events are not needed since they are not "major" unless their measurable effects persist for two consecutive annual surveys).
		LIDAR - 50cm pixel resolution for lagoon & its attending watersheds timed at last minus tide before onset of heavy winter rains, when tidal flats are at their annual lowest & least extent. Output data must be referenced to local MLLW & NAVD 88	Private or public providers; cost-sharing with other clients if possible.	Every 5 years or as required to assess major change as indicated by change in tidal range.
	Tide range	Max. & min. tide heights relative to MLLW for each tide cycle inside the lagoon but near its inlet where full tidal range can be measured.	NOAA	Continuous
	Tidal datum (MLLW, MLW, MHW, MHHW)	Continuous tide heights for each tide cycle inside the lagoon but near its inlet where full tide range can be measured. ***Note***: Accurate reckoning of tidal datum is essential to estimate tidal range, extent of mudflats, & elevation of other key habitat types.	NOAA	Continuous
	Near-shore wave energy field	Wave height, period, direction & propagation for Gulf of Farallones. Note: These data might be needed along with other tidal data identified above as input to model for predicting inlet behavior.	NOAA	Continuous
	Distribution & abundance of tidal flats	LIDAR (see information above)	Private or public providers; cost-sharing with other clients if possible.	Every 5 years or as required to assess major change as indicated by change in tidal range.
	Distribution & abundance of key intertidal habitats (not tidal flats)	1-m pixel resolution natural color geo-rectified imagery (horizontal datum to be determined).		Every 5 years

Process	Indicators	Needed Data	Data Source	Frequency of Data Collection
Fluvial flooding in selected watersheds	Stage frequency, flood frequency, & storm hydrograph for Pine Gulch Creek (PGC)	Stream gauge for water height & flow in PGC above Head-of-Tide.	??	Continuous
	Stage frequency & flood frequency for local streams other than PGC	Stream gauge for water height in selected watersheds to support modeling to predict stage frequency & flood frequency.	??	Continuous for 1-3 years.
	Distribution & abundance of active floodplain	LIDAR (see information above)	Private or public providers; cost-sharing with other clients if possible.	Once to establish base map on which hydrology can be superimposed.
		Estimates of bank full stage at reference reaches based on stream gauge output where available & Regional Curves or field indicators otherwise.	??	Every 5 years.
	Distribution & abundance of flood-prone area	LIDAR (see information above)	Private or public providers; cost-sharing with other clients if possible.	Once to establish base map on which hydrology can be superimposed.
Sediment sourcing	Distribution & abundance of major bank & hillside erosion features	LIDAR (see information above)		Every 5 years.
Sediment transport	Benthic sediment D50 & D84	Standard pebble counts at reference reaches.	??	Every 5 years.
Sediment fate	Aggradations of channel bed, floodplain, intertidal delta	Surface Elevation Tables (SETs) on floodplain of selected reaches.	??	Every 5 years.
		Marker horizons on floodplains of reference reaches & on intertidal deltas of selected watersheds.	??	Every 5 years.
		Thalweg profiles for reference reaches.	??	Every 5 years.
Water retention	Runoff coefficients	Rainfall in selected watersheds.	??	Continuous for 1-3 years.
		Stream gauge for water height in selected watersheds to support modeling to predict stage frequency & flood frequency.	??	Continuous for 1-3 years.

Table 7. Timeline: Steps to the final Locally Preferred Plan (LPP).

Task	Details	Date
Public Meeting #1	♦ Project introduction; addresses community concerns	September 19, 2007
Working Group Meetings #1-7	♦ Developed recommendations in the LPP	September 20, 2007 to April 15, 2008
Sanctuary Advisory Council (SAC)	♦ Present Draft LPP to GFNMS SAC	April 18, 2008
Release Draft LPP	♦ Post Draft LPP on web site for public comments	May 20, 2008
Public Comment Period	♦ Written comments accepted	May 20, 2008 to June 22, 2008
BLTAC Meeting	♦ Present Draft LPP	June 6, 2008
Public Workshop	♦ Present Draft LPP ♦ Working Group present for Q & A	June 11, 2008
Working Group Meeting #8	♦ Discuss public comments and possible LPP revisions	June 25, 2008
Final LPP	♦ Send to SAC for recommendation to forward onto GFNMS Superintendent	July 25, 2008
Final LPP	♦ Final LPP is forwarded onto MCOSD Executive Committee	August, 2008

For More Information, Contact:

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