Continuing Authorities Program §111 Detailed Project Report and Draft Environmental Assessment

North Half Moon Bay
Pillar Point Harbor
San Mateo County, CA

US Army Corps of Engineers
San Francisco District
South Pacific Division

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APPENDICES

CAPTIONS

BCR	Benefit Cost Ratio
CAP	Continuing Authorities Program
CDIP	Coastal Data Information Program
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CMS	Coastal Modeling System
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DO	Dissolved Oxygen
EA	Environmental Assessment
EC	Engineering Circular
EFH	Essential Fish Habitat
EPA	National Environmental Policy Act
ESA	Endangered Species Act
FONSI	Finding of No Significant Impact
IA	Initial Assessment
IDC	Interest During Construction
IWR	Institute for Water Resources
MBTA	Migratory Bird Treaty Act
MHW	Mean High Water
MLLW	Mean Lower Low Water: the local chart datum (zero depth)
MHHW	Mean Higher High Water
MMPA	Marine Mammal Protection Act
MOP	Monitoring and Prediction
MSL	Mean Sea Level
MBNMS	Monterey Bay National Marine Sanctuary
MSFMA	Magnuson Stevens Fisheries Conservation and Management Act
NED	National Economic Development
NFS	Non-Federal Sponsor (the San Mateo County Harbor District)
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service

NRMP	National Resource Management Plan
O&M	Operations and Maintenance
OMRR&R	Operation, Maintenance, Repair, Replacement, and Rehabilitation
OSE	Other Social Effects
P&S	Plans and Specifications
PS	Public Safety
RED	Regional Economic Development
SAP	Sampling and Analysis Plan
SMCHD	San Mateo County Harbor District
SPN	USACE San Francisco District
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WRDA	Water Resources Development Act

UNITS

°C	Temperature
ft	foot or feet
hr	hours
in	inches
kt	knots
m	meters (1.00 m = 3.28 ft)
mi	miles
mi^2	square miles
min	minutes
mm	millimeters
ppt	parts per thousand
s	seconds
yd^3	cubic yards

ES-1 INTRODUCTION

Pillar Point Harbor occupies the northern end of Half Moon Bay (Figure ES- 1), an arcuate, open-coast embayment that is approximately 25 miles south of San Francisco, CA. The easternmost portion of the harbor (including the East Breakwater) and the shoreline from the breakwater south to Miramontes Point are within the boundary of the City of Half Moon Bay (the city's downtown district is five miles southeast of the harbor). Three unincorporated communities – Princeton, El Granada, and Miramar – lie along the shoreline in the vicinity of the harbor.

Figure ES- 1: Aerial photograph of Pillar Point Harbor and adjacent communities. The Bay extends from Pillar Point to Miramontes Point.

At the request of local interests, the US Army Corps of Engineers (USACE) conducted a preliminary examination on the feasibility of creating a harbor at the north end of Half Moon Bay. In November 1945, USACE produced a favorable report, and in August 1947 they released a survey report of the area that recommended constructing two breakwaters to create the harbor. Congress authorized the project in 1948. Breakwater construction commenced in April 1959 and ended in June 1961. Subsequent changes to correct induced problems followed over the years.

The proposed Continuing Authorities Program (CAP) Section 111 (§111) project area comprises the harbor between the eastern inside breakwater (a non-federal project) and the East Breakwater plus 0.9 miles of shoreline extending south from the root of the East Breakwater to Arroyo de en Medio. Outside of the harbor the project footprint includes Surfer's Beach (A.K.A El Granada Beach), Vallejo Beach, and Miramar Beach.

ES-2 STUDY PURPOSE AND AUTHORITY

In FY08, the San Mateo County Harbor District (SMCHD) asked USACE San Francisco District (SPN) to investigate shoreline erosion immediately south of Pillar Point Harbor to determine if it was appropriate for the SPN to conduct a shoreline-mitigation project as specified by CAP §111. The USACE involvement would be appropriate if the East Breakwater has contributed to erosion of that stretch of shoreline. The SMCHD asserts that the shoreline was virtually stable prior to breakwater construction and that harbor creation, a USACE project, induced (a) significant beach and sea-cliff erosion immediately south of the root of the East Breakwater and (b) deposition of sand immediately north of the root (i.e., inside the harbor). They contend that the East Breakwater stopped the unimpeded flow of sand in the littoral zone thus preventing replacement of beach sand in the eroding coastal stretch.

The goal of this project is to prevent or mitigate for future economic damages in the project area in a manner that contributes to national economic development consistent with protecting the Nation's environment pursuant to national environment statutes, applicable executive orders, and other federal planning requirements. This study is conducted pursuant to §111 of the Rivers and Harbors Act (RHA) of 1998 (Publ. Law No. 90-483), which authorizes the planning of an economically justified level of work for prevention or mitigation of damages to both non-federal publicly and privately owned shores to the extent that such damages can be directly identified and attributed to federal navigation works located along the coastal and Great Lakes shorelines of the United States.

The target degree of mitigation is the reduction of shore damage to the level that would have existed without the influence of navigation works at the time such navigation works were accepted as a federal responsibility. This authority will not be used to restore shorelines to historic dimensions. The SMCHD is the non-federal sponsor (NFS) for the project.

ES-3 Prior Studies and Reports

As built, the Pillar Point Harbor project consists of two rubble-mound breakwaters. The East Breakwater – 4,420 feet long – was constructed from April 1959 to June 1961. The West Breakwater was originally 2,620 feet long when it was built from April 1959 to September 1960. Because of larger-than-expected wave energy entering the harbor, during 1966–67 a rubble-mound dogleg extension 1,050 feet long was added to the seaward end of the West Breakwater.

In 1971 the SPN studied erosion along the shoreline of E1 Granada Beach, developed a plan for arresting the erosion and for restoring the beach, and determined the economic justification of such considered improvements. The study was authorized by resolution adopted on June 19, 1963 by the Committee on Public Works, House of Representatives. The report concluded:

> The District Engineer finds that the erosion problem along the shores of El Granada Beach exists in two forms: (1) the direct erosion of material from the low bluffs immediately landward of the beach, and (2) the loss of littoral material from the beach backshore. He also finds that protective measures are required in the reach of coast from the Half Moon Bay East Breakwater to the mouth of the Arroyo de en Medio, approximately 4,600 feet to the southeast. No improvements are justified along the remaining coastline studied as the shoreline from Arroyo de en Medio to Miramontes Point is not eroding substantially at this time

In January 2006, the SPN prepared a Section 216 Initial Appraisal (IA) to respond to non-federal concerns about erosion of the Princeton shoreline inside Pillar Point Harbor. That IA concluded that, though not definitively proven, it was likely that the in-harbor deposition and down-coast erosion were caused by focusing incident wave energy onto the shoreline. Accordingly, the SPN agreed that conducting the feasibility phase of a §111 project was appropriate to determine if USACE could justify taking steps to mitigate for future damages in the area.

ES-4 Setting

This section describes the significant physical processes in the entirety of Half Moon Bay and physical changes and environmental setting in the project area since the construction of the outer breakwaters. The project comprises an area adjacent to the inside of the East Breakwater and the three beaches – El Granada Beach (habitually called Surfer's Beach), Vallejo Beach, and Miramar Beach – in the 0.9-mile stretch of shoreline between the root of the East Breakwater and the south side of the community of Miramar (Figure ES- 2).

Rubble-mound revetments front the low-lying coastal cliffs at both ends of the coastal stretch of shoreline. At the northern end, Caltrans maintains a revetment to protect Highway 1. At the southern end, San Mateo County and the City of Half Moon Bay collectively maintain a revetment to protect homes and businesses adjacent to the edge of the sea cliff in the Miramar area. The middle stretch, Vallejo Beach, is not revetted because there are no structures along the bluff edge and Highway 1 no longer abuts the bluff edge.

Figure ES- 2: Local beaches, root of the East Breakwater (black line), and revetments (red lines) Contour depths are relative to MLLW.

The Half Moon Bay shoreline extends 6.5 miles from Pillar Point to Miramontes Point. Before construction of the outer breakwaters, the bay had a smoothly arcuate shoreline comprising a continuous sandy beach backed by a sea cliff cut into a low terrace. Pillar Point and Miramontes Point constrain littoral transport to the Half Moon Bay embayment. Between those rocky headlands, waves move beach sand both cross-shore and alongshore. Over recent geologic time, the prevailing northwest swell refracted around the Pillar Point headland, eroding the shoreline into a simple log-spiral shape (Figure ES- 3) that evenly distributed wave energy along the shoreline. Once the shoreline reached this shape, incoming wave crests paralleled the coast, reducing shoreline retreat to times when storms stripped sand from the beach and both directly attacked the sea cliff and removed material that had crumbled from the cliff face because of ground water saturation. In other words, the shoreline had reached an equilibrium configuration with a low, but finite, rate of cliff retreat.

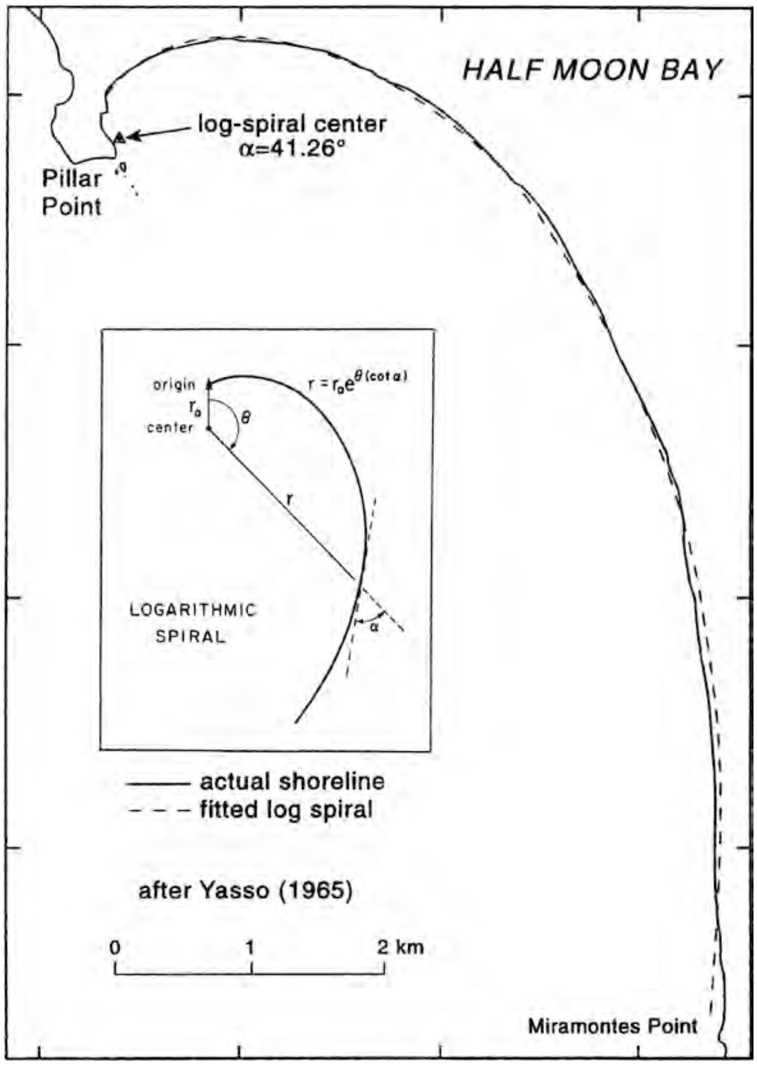

Figure ES- 3: Half Moon Bay shoreline overlain with log-spiral curve (dashed line). Inset shows the geometry of a log-spiral curve.

The longshore currents at Half Moon Bay are thought to move sand both northward and southward depending on the wave conditions with the net littoral drift being from northwest to southeast because of the predominate northerly to westerly wave climate. This reversing alongshore movement is superimposed on the onshore-offshore transport that occurs throughout the year. In general, local storms create high-energy, short-period waves that keep sand in suspension while it moves offshore (winter conditions). Lower-energy, longer-period waves slowly push the sand back onto the beach (summer conditions). If there is net longshore transport, sand from local creeks and bluff erosion are available to maintain a sandy beach. Before breakwater construction, the Pillar Point cliffs, the Princeton shoreline, and the creeks that feed that part of the bay were all sources of sand for beaches to the south.

Going back to the 1860s, Studies and historical anecdotal observations document erosion of the Half Moon Bay shoreline. This erosion is believed to have been caused by natural processes. The rate of retreat was low, however, because of the presence of a permanent sandy beach and an equilibrium shoreline shape relative to the incident waves. Because Half Moon Bay is essentially a closed system (littoral cell) and there is a continuous sand supply from cliff erosion and creek input, littoral sand must either be lost to the offshore or dunes unless beach width increases. Studies show that the bay's beaches are not accreting, and in the project area there is no beach at higher tides.

Construction of the East Breakwater disrupted the equilibrium wave pattern and focused wave energy at the low cliffs south of the breakwater causing rapid cliff erosion along the shoreline in area of this project. Post-breakwater construction in that area, a county road was destroyed, state Highway 1 threatened, and the rate of sea cliff retreat increased from three inches per year to 80 inches per year. Specifically, by 1985 the sea cliff had eroded far enough into the terrace to destroy Mirada Road, which paralleled the cliff edge. The most likely causes of the increased erosion are shifting the center of the log-spiral to the south and cutting off the sand supply from the north. Shifting the center of the spiral creates a different wave-energy dynamic along the length of Half Moon Bay as the shoreline tries to return to an equilibrium configuration. The greatest change will be where the spiral is the tightest, which is adjacent to the south side of the East Breakwater. The effect will taper off downcoast, and erosion will, consequently, be less.

Inside the harbor, there is a sand wedge adjacent to the East Breakwater that includes a beach and small vegetated dunes. In April 1998 the beach contained, at least 73,000 yd^3 of exposed sand[1]. This volume does not take into account the tide level, which ranged from MLLW to +4 ft during the day of the LIDAR survey, and changes in volume since 1998 are unknown. Between that beach and the inner breakwater, sufficient sand has accumulated to elicit concern from the SMCHD about restricted small-boat access to the inner harbor via the east entrance.

ES-5 PLAN FORMULATION

This section discusses the formulation of alternatives for preventing or mitigating for future economic damages along the Half Moon Bay shoreline in the vicinity of the East Breakwater of Pillar Point Harbor. It sets forth the most environmentally sound, economically feasible, and socially beneficial alternative that does not result in environmental degradation. This section discusses problems, opportunities, restoration objectives, and constraints within the study.

The USACE is required to consider the option of "No Action" as one of the alternatives to comply with the requirements of the National Environmental Policy Act (NEPA). No Action assumes that no project would be implemented by the federal government to achieve planning objectives. No Action, which is also referred to as the "Without Project Conditions", forms the basis from which all other alternative plans are measured. The No-Action alternative characterizes current and anticipated future conditions at the project site in the absence of the proposed action to address beach and bluff erosion. Under the No-Action plan, USACE would do no mitigation efforts in the vicinity of the East Breakwater at Pillar Point Harbor.

The proposed action would involve dredging approximately 140,000 to 150,000 cubic yards (yd^3) of sand accumulated along the inside of Pillar Point Harbor's East Breakwater and a one-time placement of that sand to form a 125-foot wide elevated berm along the approximately 3,100-foot long section of shoreline that makes up Surfer's and Vallejo beach's in Half Moon Bay. Alternatives considered but eliminated are:

- Maximum Beach Fill Alternative

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[1] Calculation is based on data from the1998 Spring West Coast Post-El Niño LIDAR flights. NAVD88, which is the same as MLLW in the area (MLLW is -0.08 ft higher), is the datum. Flight time was not given, so tidal level cannot be included.

- Sealing the East Breakwater
- Creating a Notch in the East Breakwater
- Alternative Dredged Material Placement
- Spur Breakwater
- Managed Retreat

ES-6 Environmental Conditions

The draft environmental assessment and 404(b)(1) analysis are being prepared for USACE's feasibility review process during which federal interest in the project will be evaluated. In summary, the proposed action would not have significant adverse indirect or cumulative impacts on the physical, biological, and human environment. Temporary and minor direct adverse effects associated with the proposed action are expected to be short in duration and would end on completion of construction. They would be less than significant given the assumed avoidance measures and BMPs described in the draft Environmental Assessment (Environmental Appendix). Long-term impacts of the proposed action would be beneficial in terms of minimizing erosion, removing navigational hazards, and improving recreation and habitat at the project site.

The USACE will not make a NEPA determination on the project unless it is determined during the feasibility phase that there is a federal interest in conducting the project. Because federal interest in this project is not established, this document has not been released for public and agency review and comment and is not accompanied by a draft Finding of No Significant Impact (FONSI) or other environmental compliance permits.

ES-7 Economic Analysis

The primary purpose of this Economic Analysis is to determine Federal Interest for project implementation. A benefit-cost analysis will be performed for one or more project alternatives that considers total National Economic Development (NED) benefits and total NED costs. Expected economic damages along the shoreline that are attributable to the existingFederal East Breakwater at Pillar Point Harbor will be evaluated and NED benefits via a reduction of damages will be estimated for potential measures that could be implemented to mitigate for the adverse impacts caused by the breakwater.

This Economic Analysis was prepared in accordance with current principles and guidelines and standard economic practices, as outlined in the Planning Guidance Notebook (PGN) – ER

1105-2-100, as well as the Institute for Water Resources (IWR) Report 2011-R-09, *Coastal Storm Risk Management National Economic Development Manual*. The base year (the first year in which a project could be implemented) is assumed to be 2017. All discounting is done using the 2015 federal water resources discount rate of 3.375%[2]. For reasons that are described in the report, a 20-year period of analysis was chosen. Guidance and procedures for estimating recreation value came from USACE Economic Guidance Memorandum (EGM) 15-03 and the PGN.

Below is a list of the NED categories that are typically considered for this type of study according to IWR Report 2011-R-09. Not all of these damage categories will be relevant for all studies.

- Property Damage
- Recreation Impacts
- Land Loss
- Transportation Delay Cost
- Emergency Cost
- Income Loss

USACE policy considers NED benefits associated recreation incidental when it comes to project economic justification.

The without-project (No-Action) condition, as its name suggests, is an assessment and forecast of the risks, assumptions, and conditions, assuming no USACE action. If erosion risk-reduction (or in-harbor sand removal) measures or any other actions are imminent or likely during the period of analysis without USACE's action, those measures and actions should be considered to be part of the without-project condition. For coastal studies such as this, the consideration of future actions by others is especially important to the benefit-cost-analysis of the project. The critical future without-project assumptions of this analysis are:

- *Bluff Erosion Rate*: Any areas of the shoreline unprotected by a rock revetment in the study area will experience an average rate of bluff erosion of 1.6 ft./yr. According to the Coastal Engineering Appendix, the "natural" background rate of erosion is approximately 0.2 ft./yr.,

[2] The 2017 federal discount rate is slightly lower (2.875%) than 2015 rate applied for this analysis. Applying the 2017 discount rate would have very little impact on the with-project net benefits estimate and would not change the final conclusion or recommendation.

so the federal breakwater is assumed to cause 1.4 ft./yr. of erosion to the stretch of the study area where no revetment exists.

- *Cabrillo Highway (CA-1)*: The previously-described project planned by Caltrans and San Mateo County to protect and improve the exposed stretch of the Highway 1 and the coastal trail will be completed before any federal project could be implemented.
- *Boat Ramp*: The boat ramp area will continue to accumulate sand, and periodic dredging will be necessary to provide safe and reliable access. The most recent three dredging episodes were in 1998, 2006, and 2013. The most recent dredge episode cost just over $530,000[3]. It is assumed that in the future dredging will continue to be required every seven years to maintain safe access to and use of the boat ramp.
- *Mirada Road Homes and Businesses*: The protective riprap that is in place along the bluff adjacent to Mirada Road will be maintained such that Mirada Road, adjacent homes, and businesses in the area will not be significantly adversely affected by future erosion.
- *20-year Period of Analysis:* According to the PGN, the period of analysis is defined as the duration of time over which the project will have significant beneficial or adverse impacts. The period of analysis must be the same for all alternatives considered. Although the engineering analysis estimates that some beneficial effect of the final array of alternatives could extend as long as 40 or 50 years from project completion, it is likely that the benefits after 20 or 30 years would be small because the visible beach for the beach fill alternatives will likely have disappeared within 10 years of project implementation.

Implementing the medium fill alternative would be expected to widen the beach for at least six years under typical non-El Niño conditions. While there is a significant degree of uncertainty, it was assumed for this analysis that the visible beach created by this beach fill project would last for nine years. This assumption was made because the estimate of six years assumed a linear rate of annual sand loss, which, according to the Coastal Engineering Appendix, "likely overestimates the rate of loss after the initial period of adjustment to ambient hydrodynamic conditions." A 50% increase over the modeled lifespan of the visible beach was determined to be reasonable based on the professional judgment of the project team.

Compared to the without-project NED impacts, the with-project damages to recreation are simply delayed by nine years. Additional loss in land value from bluff erosion is assumed to be

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3 Source: San Mateo County Harbor District

delayed for at least the twenty-year period of analysis because placed sand is expected to persist in the nearshore for up to forty years.

Table ES- 1 shows the results of the benefit-cost analysis for the Medium Beach Fill alternative. The annual damages reduced is the difference between the without- and with-project average annual damages, the net benefits are the difference between the average annual damages reduced and the average annual project costs, and the benefit-cost ratio is the ratio of average annual damages reduced and average annual costs. The results show that the alternative is not economically justified. If analyzed assuming a higher opportunity cost of capital (greater discount rate), the benefit-cost ratio would be even lower. If the recreation benefits of the project were constrained to no more than 50% of the total benefits needed for justification, the benefit-cost ratio would be significantly lower than shown here.

Table ES- 1: Benefit Cost Analysis Results - Medium Beach Fill Alternative

Without-Project Average Annual Damage	$198,510
With-Project Average Annual Damage	$112,737
Average Annual Damages Reduced	$85,773
Average Annual Costs	$348,000
Annual Net Economic Benefits	**($262,227)**
Benefit-Cost Ratio (3.375%)	**0.25**

ES-8 Conclusions and Recommendations

The preferred alternative would involve a one-time dredging of approximately 140,000 to 150,000 yd^3 of sand accumulated along the East Breakwater and placement of that sand to form a 125-foot wide elevated berm along the approximately 3,100-foot long section of shoreline that makes up Surfer's and Vallejo Beaches. The proposed action would not have significant adverse indirect or cumulative impacts on the physical, biological, and human environment. Temporary and minor direct adverse effects associated with the proposed action are expected to be short in duration, ending with the completion of construction activities, and would be less than significant given the assumed avoidance measures and BMPs described in this assessment. Long-term impacts of the proposed action would be beneficial in terms of minimizing erosion, removing navigational hazards, and improving recreation and habitat at the project site.

Because the NED analysis shows the benefit-to-cost ratio for the proposed action is 0.25, and a ratio greater than 1.00 is needed to justify federal action by USACE, a federal project is not recommended. If another entity decides to go forward with a similarly designed project, the results of the economics, engineering, and environmental analyses will be available through the NFS (the SMCHD). There are still opportunities to address erosion at Surfers Beach through the continued efforts and partnership of the Harbor Commission, the Beach Replenishment Committee, Caltrans, and the other agencies with the support of the MBNMS.

1 INTRODUCTION

At the request of the SMCHD, the San Francisco District (SPN) of the USACE investigated inveterate coastal storm damage in the vicinity of the East Breakwater of Pillar Point Harbor, Half Moon Bay, to determine whether there is a federal interest in mitigating for damages that occurred after construction of the harbor, a federal navigation project. Purported damages comprise excessive deposition inside the harbor and greatly accelerated shoreline erosion immediately south of the harbor. The SMCHD asserted that the shoreline was virtually stable prior construction of the East Breakwater, and the breakwater stopped the unimpeded flow of sand in the littoral zone thus preventing the replenishment of beach sand in the eroding coastal stretch.

Involving USACE would be appropriate if the East Breakwater were a major contributor to that deposition and erosion. If USACE determines that its breakwater has played a major role in the shoreline erosion, it could initiate a project using its continuing authorities program. If the feasibility phase of that project demonstrates a federal interest, the implementation phase might result in:

- transferring clean, non-contaminated harbor sand to the beach immediately outside and adjacent to the East Breakwater,
- modifying the root of the East Breakwater to better manage longshore sand transport,
- constructing a hard structure along the face of the sea cliff to prevent further shoreline retreat, or
- creating a sand "reef" just offshore of the beach to reduce the amount of and need for periodic sand replenishment on the beach.

Any project would have to be economically viable or address associated navigational issues in the project area. The USACE's responsibilities with respect to such mitigation are specified by the CAP §111.

1.1 LOCATION

Pillar Point Harbor is a small-craft harbor located approximately 25 miles south of San Francisco in San Mateo County, CA. Primarily the harbor serves commercial fishing vessels and recreational boats. The nearest incorporated city is Half Moon Bay, which covers approximately 6.5 square miles of land. The population of the city was approximately 13,000 residents in 2013, and the top employing industries in the city are accommodation and food services; retail trade; and arts, entertainment, and recreation.

The harbor sits at the northern end of Half Moon Bay, which is an open embayment located between Pillar Point and Miramontes Point (Figure 1). The bay's 6.5-mile-long, smoothly arcuate (hook shaped) shoreline comprises a broad, sandy beach backed by a low coastal terrace. The easternmost portion of the harbor (including the root of the East Breakwater) and the shoreline from the breakwater south to Miramontes Point are within the boundary of the City of Half Moon Bay – the city's downtown district is five miles southeast of the harbor. Besides Half Moon Bay, the closest communities to the harbor are Princeton (which borders the northwestern portion of the harbor) and El Granada (east across Highway 1).

Figure 1: Aerial photograph of Pillar Point Harbor and adjacent communities. The Bay extends from Pillar Point to Miramontes Point.

1.2 Existing Authorized Project

At the request of local interests, USACE conducted a preliminary examination on the feasibility of creating a harbor at the north end of Half Moon Bay. In November 1945, USACE produced a favorable report, and in August 1947 they released a survey report of the area that recommended constructing two breakwaters to create the harbor. Congress authorized the project in 1948. Breakwater construction commenced in April 1959 and ended in June 1961. Subsequent changes to correct induced problems followed over the years, Pillar Point Harbor (under the project name of Halfmoon [*sic*] Bay, California), as described in House Document No. 644, 80th Congress, 2nd Session, was authorized in the River and Harbor Act of 1948:

> The following works of improvement of rivers and harbors and other waterways for navigation, flood control, and other purposes are hereby adopted and authorized to be prosecuted under the direction of the Secretary of the Army and supervision of the Chief of Engineers, in accordance with the plans and subject to the conditions recommended by the Chief of Engineers in the respective reports hereinafter designated: Provided, That the provisions of section I of the River and Harbor Act approved March 2, 1945 (Public, Numbered 14, Seventy-ninth Congress, first session), shall govern with respect to projects authorized in the title, and the procedures therein set forth with respect to plans, proposals, or reports for works of improvement for navigation or flood control and for irrigation and purposes incidental thereof, shall apply as if herein set forth in full:…Halfmoon [*sic*] Bay California; House Document Numbered 644, Eightieth Congress;

The recommendations authorized by this act are described in the report from the San Francisco District Engineer dated 1 August 1947:

> The district engineer recommends that Halfmoon [*sic*] Bay, Calif., be improved by the construction of two rubble-mound breakwaters, each approximately 4,400 feet long, substantially as shown on the plan of improvement submitted herewith, at an estimated cost of $4,512,000 for new construction, and $43,800 annually for maintenance, subject to conditions that local interests establish a competent and properly constituted public body, empowered to regulate the use, growth and free development of the harbor facilities with the understanding that such facilities shall be open to all on equal and reasonable terms,…

Pillar Point Harbor is confined by two rubble-mound breakwaters (referred to as the East and West Breakwaters, or collectively as the Outer Breakwaters) and the northernmost Half Moon Bay shoreline (Figure 2). The West Breakwater, which was originally 2,620 feet long, was constructed from April 1959 to September 1960. Because of larger-than-expected wave energy entering the harbor during 1966 and 1967, a 1,050-foot-long rubble-mound dogleg extension was added to the seaward end of the West Breakwater. In 1996 a concrete parapet wall measuring 109-feet long by 3-feet high by 3-feet thick was added to the root of the West Breakwater with additional protection being provided by one layer of armor stone covering the parapet wall.

Figure 2: CAP §111 project area and vicinity.

The East Breakwater, which is 4,420 feet long, was constructed between April 1959 and June 1961. Following construction of the East Breakwater, the erosion rate of the coastal bluff immediately to the south increased dramatically, suggesting a cause-and-effect relationship between construction and erosion.

1.3 Proposed CAP §111 Project

The proposed CAP §111 project area comprises the harbor between the eastern inside breakwater (a non-federal project) and the East Breakwater plus 0.9 miles of shoreline extending south from the root of the East Breakwater to Arroyo de en Medio (Figure 2). Outside of the harbor the project footprint includes Surfer's Beach (A.K.A El Granada Beach), Vallejo Beach, and Miramar Beach (Figure 3). Rubble-mound revetments front the low-lying coastal cliffs at both ends of the coastal stretch of shoreline. At the northern end, Caltrans maintains a revetment to protect Highway 1. At the southern end, San Mateo County and the City of Half Moon Bay collectively maintain a revetment to protect homes and businesses adjacent to the edge of the sea cliff in the Miramar area. The middle stretch, Vallejo Beach, is not revetted because there are no structures along the bluff edge and Highway 1 no longer abuts the bluff edge.

Figure 3: Local beaches, root of the East Breakwater (black line), and revetments (red lines) Contour depths are relative to MLLW.

In Fiscal Year 2008 (FY08), the SMCHD asked USACE to investigate deposition inside Pillar Point Harbor and shoreline erosion immediately south of the harbor to determine if it was appropriate for the SPN to conduct a shoreline-mitigation project as specified in CAP §111. USACE Involvement could be appropriate if the East Breakwater contributed to the increased deposition and erosion in that stretch of shoreline. The SMCHD asserted that the shoreline was virtually stable prior to harbor creation and that construction of the East Breakwater (part of the USACE project that created Pillar Point Harbor).

- induced significant deposition of sand immediately north of the root of the breakwater,
- focused wave energy on the stretch of coast south of the breakwater causing dramatic beach loss and sea-cliff erosion, and
- stopped the unimpeded southward flow of sand in the littoral zone thus preventing the replenishment of beach sand in the eroding coastal stretch

In responding to SMCHD's request, USACE conducted a §216 IA to determine if its breakwater has played a major role in the shoreline erosion. Based on the findings of the IA, USACE decided to conduct a study to determine the feasibility of mitigating for future shoreline changes in the area. This Detailed Project Report (DPR) is the document that describes the findings of the feasibility study.

2.1 Goal

The goal of this project is to mitigate for future damages in the project area in a manner that contributes to national economic development consistent with protecting the Nation's environment pursuant to national environment statutes, applicable executive orders, and other federal planning requirements. If the project is constructed, potential solutions include

- transferring clean, non-contaminated harbor sand to the beach immediately outside and adjacent to the East Breakwater;
- modifying the root of the East Breakwater to better manage longshore sand transport,
- constructing a hard structure along the face of the sea cliff to prevent further shoreline retreat or address associated navigational issues in the project area, or
- creating a sand "reef" just offshore of the beach to reduce the amount of and need for periodic sand replenishment on the beach;

2.2 Authority

This study is conducted pursuant to §111 of the Rivers and Harbors Act (RHA) of 1998 (Publ. Law No. 90-483), which authorizes the planning of a justified level of work for prevention or mitigation of damages to both non-federal publicly and privately owned shores to the extent that such damages can be directly identified and attributed to federal navigation works located along the coastal and Great Lakes shorelines of the United States. Specifically, the Secretary of the Army is authorized to investigate, study, plan, and implement structural and nonstructural measures for the prevention or mitigation of shore damages attributable to federal navigation works, if a non-federal public body agrees to operate and maintain such measures, and, in the case of interests in real property acquired in conjunction with nonstructural measures, to operate and maintain the property for public purposes in accordance with regulations prescribed by the Secretary. The costs of implementing measures under this section shall be cost-shared in the same proportion as the cost-sharing provisions applicable to the project causing the shore damages. The target degree of mitigation is the reduction of shore damage to the level that would have existed without the influence of navigation works at the time such navigation works were accepted as a federal responsibility. This authority will not be used to restore shorelines to historic dimensions.

Several studies of coastal erosion south of the root of the East Breakwater have been conducted since breakwater construction. This section presents the two most pertinent to the present project.

3.1 Beach Erosion Control Report on the Shores of El Granada Beach, San Mateo County, California (1971)

This study analyzed the erosion problems along the shoreline of E1 Granada Beach, developed a plan for arresting the erosion and for restoring the beach, and determined the economic justification of such considered improvements. The study was authorized by resolution adopted on June 19, 1963 by the Committee on Public Works, House of Representatives, which reads:

> Resolved by the Committee on Public Works of the House of Representatives, United States, in accordance with Section 110 of the River and Harbor Act of 1962, that the Secretary of the Army be and is hereby requested to cause to be made, under the direction of the Chief of Engineers, a survey of the shores of the E1 Granada Beach, San Mateo County, California, and such adjacent shores as may be necessary in the interest of beach erosion control and related purposes

The report concluded:

> The District Engineer finds that the erosion problem along the shores of El Granada Beach exists in two forms: (1) the direct erosion of material from the low bluffs immediately landward of the beach, and (2) the loss of littoral material from the beach backshore. He also finds that protective measures are required in the reach of coast from the Half Moon Bay East Breakwater to the mouth of the Arroyo de en Medio, approximately 4,600 feet to the southeast. No improvements are justified along the remaining coastline studied as the shoreline from Arroyo de en Medio to Miramontes Point is not eroding substantially at this time

3.2 §216 Review of Completed Projects (§216 IA)

As part of its completed projects (§216) authority, USACE can review completed projects because of changed physical conditions. The purpose of the IA was to review the existing USACE project – Pillar Point Harbor (authorized in 1948 with initial breakwater construction from 1959 to 1961) – to determine whether it is appropriate for USACE to participate in the mitigation of future in-harbor deposition and erosion, accompanied by structural damage, along the northern open-ocean shoreline of Half Moon Bay. The non-federal sponsor has stated that the negative shoreline impacts in that area can be attributed to the original USACE project. The increased deposition and erosion rates represent a change in physical condition for the Pillar Point Harbor project.

The area of concern starts inside the East Breakwater; outside it extends southward from the breakwater root a distance of approximately one mile to Arroyo de en Medio, which is near the southern end of Miramar Beach (Figure 2). Because of its relative stability since breakwater construction, the Half Moon Bay shoreline between Arroyo de en Medio and Miramontes Point was not included in the IA. Federal interest was based on two factors:

1. the extent of the post-construction shoreline change beyond the natural change that would have been expected without the Pillar Point Harbor project
2. the economic viability of a potential project to mitigate for such physical changes. If USACE determines that there is a federal interest, it will implement a remedial project.

Section 216 of the River and Harbor and Flood Control Act of 1970 (P.L. 91-611) as amended states:

> The Secretary of the Army, action through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.

The Section 216 process starts with the preparation of an Initial Appraisal. As stated in Engineer Regulation ER 1105-2-100, the cost of preparing an Initial Appraisal report is limited to $20,000. The U.S. Army Corps of Engineers, San Francisco District allocated $20,000 in Fiscal Year 2008 Operation and Maintenance funds to conduct this Initial Appraisal

This section describes the significant physical processes in the entirety of Half Moon Bay and physical changes and environmental setting in the project area since the construction of the outer breakwaters.

4.1 Shoreline Configuration

The Half Moon Bay shoreline extends 6.5 miles from Pillar Point to Miramontes Point (figure imbedded in Table 1). Before construction of the outer breakwaters, the bay had a smoothly arcuate shoreline comprising a continuous sandy beach backed by a sea cliff cut into a low terrace (Table 1). The terrace tilts upward from north to south with an elevation range of approximately10 to 60 feet. In the central part of the bay, small coastal sand dunes replace the terrace. The San Mateo County geologic map shows that the terrace consists of Holocene unconsolidated fine- to coarse-grained sand, silt, and gravel to the north and Pleistocene poorly consolidated and poorly indurated well- to poorly-sorted sand and gravel to the south. Pillar Point consists of marine conglomerate, sandstone, and shale of the Merced formation; Point Miramontes consists of fossiliferous shale of the Purisima formation located unconformably under Pleistocene deposits. Extensive rocky reefs occur at both points.

Table 1: Shoreline between Miramontes Point and Pillar Point (Krumbein, 1947).

Site	Shoreline Description
1	Rock reefs abundant, sand very coarse, beach fairly narrow, cliffs 60 feet high, erosion evident.
2	Occasional rock reefs, coarse sand, cliffs 50-60 feet high, erosion evident.
3	Well-developed berm, cliffs 40 feet high.
4	Well-developed berm, cliffs 20 feet high.
5	Well-developed berm, sand moderately coarse, sand dunes on terrace.
6	Berm present, stream parallels cliff inland of beach. Cliff 15 feet high.
7	Well-developed berm, prominent dune belt' parallels wide beach.
8	Well-developed berm, dune belt ends just north of station.
9	Partially eroded berm, wide beach, sand moderately fine. Cliffs 10 feet high.
10	No berm present, wide beach, sand rather fine. Some erosion evident. Cliffs 10 feet high.
11	No berm present, active erosion along cliffs, which are 20 feet high.
12	Small trace of berm in re-entrant. Wide beach, very fine dark sand. Very active erosion along cliffs, which are 15 feet high.
13	No berm present. Very wide beach, very fine dark sand, always moist. Cliff here about 1 to 2 feet high.

Krumbein (1947) reported that on 11 April 1942 beach width diminished irregularly from 250 ft just east of Pillar Point to 140 ft just north of Miramontes Point. "During subsequent visits, [it] widened to some extent along its entire course." Both the foreshore slope and beach-face sand size decreased from south to north, which is consistent with a decrease in wave energy in that direction.

Pillar Point Harbor sits at the northern end of Half Moon Bay (Figure 1 & Figure 4), enclosing 1.6 miles of the shore and creating a safe haven for private and commercial marine operations. Along the open coast, most of the beach access is north of Poplar Street (3.6 miles south of the root of the East Breakwater), which is the southern limit of the urban area of the city. Miramar, Naples, Dunes, and Francis California State Beaches lie between Arroyo de en

Medio and Kelly Street (2.9 mi south of the breakwater). Farther south, the area has been sparsely developed, being mostly used for agriculture; however, private residences, hotels, and a golf resort have recently appeared (Griggs et al., 2005).

Figure 4: 1971 aerial photograph of Half Moon Bay looking south with the East Breakwater in the foreground and Miramontes Point in the distance. Note the sand wedge adjacent to the harbor side of the root of the East Breakwater. Photograph by N. Prime, USGS.

Pillar Point and Miramontes Point constrain littoral transport to the Half Moon Bay embayment (Lajoie and Mathieson, 1985). Between those rocky headlands, waves move beach sand both cross-shore and alongshore. Over recent geologic time, the prevailing northwest swell refracted around the Pillar Point headland, eroding the shoreline into a simple log-spiral shape (Figure 5) that evenly distributed wave energy along the shoreline (Lajoie and Mathieson, 1985). Once the shoreline reached this shape, incoming wave crests paralleled the coast, reducing shoreline retreat to times when storms stripped sand from the beach and both directly attacked the sea cliff and removed material that had crumbled from the cliff face because of ground water saturation (Hampton 2002, Collins and Sitar 2008). In other words, the shoreline had reached an equilibrium configuration with a low, but finite, rate of cliff retreat (Griggs et al., 2005).

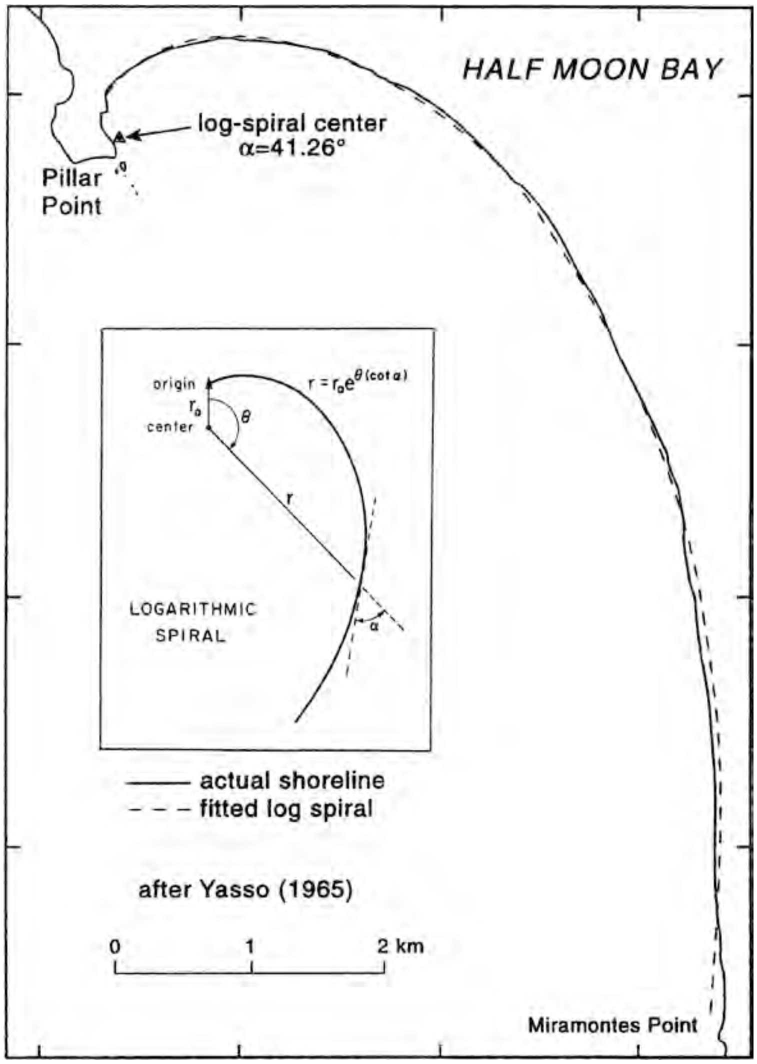

Figure 5: Half Moon Bay shoreline overlain with log-spiral curve (dashed line). Inset shows the geometry of a log-spiral curve.

Grain size, beach slope, and wave energy all increase from north to south. Numerous field studies have quantitatively demonstrated that beaches composed of coarse particles have steeper slopes (Komar, 1998, p. 285). The studies also show that beach slope increases with increasing wave energy for a given grain size. Since the northern end of Half Moon Bay is protected from northwest waves while the southern end is fully exposed to all wave directions, wave energy is lowest close to the headland and progressively increases to the south. In response to the increasing energy level, the beaches farthest from the headland are coarsest – there is a systematic increase in grain size in that direction (0.17 mm mean diameter near Princeton to 0.65 mm at Miramontes Point [Bascom 1951]). Consequently, beach-face slope increases from north to south.

4.2 Winds

The central California Coast sits on the eastern edge of a high-pressure system over the eastern North Pacific Ocean. The location of that system throughout the year determines the predominant meteorological conditions for the region. Normally, the North Pacific high-pressure system shifts north during the summer and south during the winter. The position of high pressure offshore in combination with lower pressure in the warm inland areas results in west-northwesterly to northwesterly winds throughout much of the year (Mass and Bond, 1996; Renard, ND).

Between May and October when the high-pressure system is at a more northern location, the mean wind direction is from the west northwest to northwest (Halliwell and Allen, 1987). When the high-pressure region shifts south between November and April, the mean wind direction is from the west (Halliwell and Allen, 1987; Dorman et al., 1995; Dorman and Winant, 1995).

Besides the North Pacific high-pressure system, migratory weather systems produce local variations in the climate throughout the year. During the winter months, southeasterly to southwesterly winds form in advance of extratropical storms that cross the region. During the summer months, the development of higher pressure over the interior part of the state results in offshore flow (Mass and Bond, 1996).

Land and sea breezes constitute an important component of the local wind regime. Cooler air over land than over the ocean creates a land breeze (offshore flow); warmer air over land than over the ocean creates a sea breeze (onshore flow). Typically, the land warms up during the day with a maximum air-temperature difference in the early to midafternoon. This produces a surface pressure differential between the ocean (high) and land (low) resulting in a strong, steady sea breeze. Subsequently, the land cools, and sometime after sunset the two temperatures are equal and the wind dies. Further cooling can result in a land breeze. In central California, this pattern can occur at any time of the year.

The wind climate at Pillar Point Harbor has not changed significantly since the construction of the outer breakwaters. The average wind speed over a year is between five to fifteen miles per hour. While the predominant winds come from the northwest, the most severe winds come from the south. The fastest wind speed for a return period of fifty years is estimated to be sixty-one miles per hour.

4.3 Currents and Tides

The currents offshore of Half Moon Bay consists of the California Current flowing southward throughout the year and the Davidson Current flowing northward shoreward of the California Current, typically in the fall and the winter. These currents do not have a direct effect on the nearshore circulation, which is dominated by tides, waves, and wind-driven circulation. Eddies rotating counterclockwise in the northern portion and clockwise in the southern portion of Half Moon Bay were believed to exist prior to construction of the outer breakwaters. That construction probably altered this circulation pattern by either shifting the eddies to the south or eliminating them altogether.

4.4 Sea-Level Fluctuations and Storms

Sea-level fluctuations include tidal cycles, storm set up, and long-term rise caused by natural processes and human impacts. The tides at Half Moon Bay are mixed semidiurnal tides with a great diurnal tide range of 5.5 feet, and a mean sea level elevation of 3.0 feet relative to Mean Lower Low Water (MLLW), which is the datum for local nautical charts. The construction of the outer breakwaters should not have affected the tidal amplitudes, but they could have had a major effect on the tidal currents. The state of the tide is important with respect to coastal erosion because storms that strike the coast during high spring tides are more likely to inflict major damage than those that strike during lower parts of the tidal cycle. For example, the California coast suffered significant storm damage during 1982–83 and 1997–98, both El Niño years. Although several indices suggest that the 1997-98 El Niño was stronger than the one in 1982-83, the earlier one caused far more coastal damage (Griggs et al., 2005). A major difference between the two El Niños is that the largest two storms of the earlier one hit during high spring tides while the largest two storms of the later one hit during lower tides.

El Niños are cyclic, and along the California coast they were less severe during the period between mid-1940s and 1978 than during the period between 1978 and 1998 (Figure 6). Coastal erosion and storm damage along the California coast are maximized when several processes occur simultaneously. Historical reviews focused on the central California coast show that about 75 percent of the storms that caused significant erosion or structural damage between 1910 and 1995 occurred during El Niños (Griggs et al., 2005).

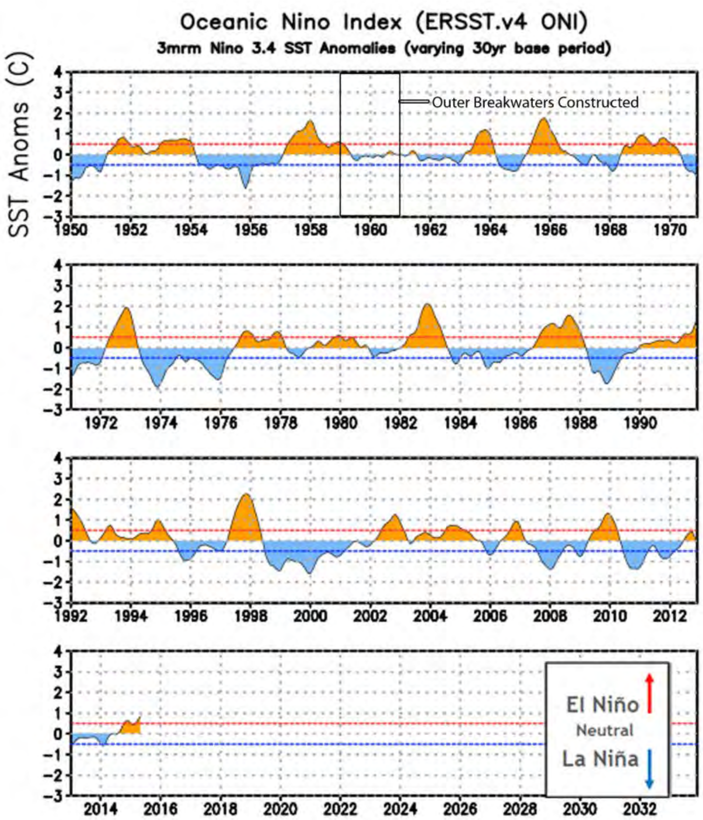

Figure 6: A fifty-year history of ENSO conditions (NOAA, 2015).

4.5 Waves

The construction of the outer breakwaters has had a dramatic effect on the northern portion of Half Moon Bay. While the head of Pillar Point provided some natural protection from waves traveling from the north-to-west directions, the magnitude of wave reduction became much less after the construction of those breakwaters and the West Breakwater extension. Prior to the construction of the breakwaters waves originating from the northwest would refract around Pillar Point. The construction of the breakwaters altered the wave refraction causing the waves to have a head-on impact on the beaches adjacent to the East Breakwater. Consequently, waves from the northwest direction have a more dramatic effect on that area now than prior to the breakwater construction.

4.6 Tributary Streams and Sediment Supply

From north to south, the streams that enter Half Moon Bay are Denniston Creek, Deer Creek, Arroyo de en Medio, Frenchman Creek, and Pilarcitos Creek. Denniston Creek and Deer Creek drain into Pillar Point Harbor, and the rest directly enter the ocean through the beach. Deer Creek and Arroyo de en Medio drain into the project area. The former enters at the root of the inner breakwater next to the boat ramp, and the latter enters at the south end of Miramar Beach.

4.7 Water Quality

Typical water quality indicators include temperature, salinity, pH, turbidity, suspended solids, natural light transmission (transmissivity), and dissolved oxygen (DO). Table 2 characterizes typical water quality parameters for May to August that were compiled from several sample points near Pillar Point Harbor's East Breakwater (USACE, 2006).

Table 2: Pillar Point Harbor Water-Quality Characteristics (Source: USACE, 2006)

Parameter	Typical results from May to August
Temperature (°C)	9 to 15
Salinity (ppt)	33 to 34.5
Transparency	160 to 230
DO at surface (% saturation)	85 to 130
DO at bottom (% saturation)	70 to 120

Water quality in Pillar Point Harbor has been considered chronically impaired because of the presence of high fecal indicator bacteria (FIB) counts, primarily in the vicinity of Capistrano Beach, which is immediately west of the west inner breakwater (Kim and Wuertz,). The FIB counts were usually low at all of the other in-harbor beaches.

4.8 Littoral Drift

The littoral drift at Half Moon Bay is thought to move both northward and southward depending on the wave conditions with the net drift being from northwest to southeast because of the predominate northerly to westerly wave climate. This reversing alongshore movement is superimposed on the onshore-offshore transport that occurs throughout the year. In general, local storms create high-energy, short-period waves that keep sand in suspension while it moves offshore (winter conditions). Lower-energy, longer-period waves slowly push the sand back onto the beach (summer conditions). If there is net longshore transport, sand from local creeks and bluff erosion are available to maintain a sandy beach. Before breakwater construction, the Pillar Point cliffs, the Princeton shoreline, and the creeks that feed that part of the bay were all sources of sand for beaches to the south.

Because Half Moon Bay is essentially a closed system (littoral cell) and there is a continuous sand supply from cliff erosion and creek input, littoral sand must either be lost to the offshore or dunes unless beach width increases. Studies show that the bay's beaches are not accreting, and in the project area there is no beach at higher tides. Krumbein (1947) concluded that little sand moved into the dune field, but approximately 30,000 yd^3 moved offshore annually.

4.9 Shoreline Erosion

4.9.1 Studies Prior to Breakwater Construction

Going back to the 1860s, Studies and historical anecdotal observations document erosion of the Half Moon Bay shoreline. This erosion is believed to have been caused by natural processes. The rate of retreat was low, however, because of the presence of a permanent broad sandy beach and an equilibrium shoreline shape relative to the incident waves (Griggs et al., 2005).

4.9.2 Impact of Pillar Point Harbor

Table 3 summarizes the major construction at Pillar Point Harbor and gives the shoreline condition in the project area at the time of the construction. The results suggest a link between construction of the outer breakwaters and an increased erosion rate of the adjacent shoreline.

Table 3: Construction at Pillar Point Harbor and Shoreline Condition

Date	Event	Beach Condition
Prior to 1959	Natural Conditions	Minimal erosion with broad sandy beach
1959 to 1965	Two Outer Breakwaters Built	Increased erosion with a loss of approximately 75,000 yd^3 per year (USACE, 1971)
Prior to 1971	500-ft revetment built southward starting at root of East Breakwater	Stopped local cliff retreat (USACE, 1971)
1982	Two Inner Breakwaters Built	No impact on erosion south of the East Breakwater
1965 to present	Various remedial actions including rubble-mound revetments	Erosion rates increased from 3 in per year to as much as 80 in per year where the sea cliff is exposed (Griggs et al., 2005).

4.9.3 Effects of the East Breakwater on the Adjacent Shoreline

Inside the harbor, there is a sand wedge adjacent to the East Breakwater (Figure 7) that includes a beach and small vegetated dunes. In April 1998 the beach contained, at least 73,000

yd^3 of exposed sand[4]. This volume does not take into account the tide level, which ranged from MLLW to +4 ft during the day of the LIDAR survey, and changes in volume since 1998 are unknown. Between that beach and the inner breakwater, sufficient sand has accumulated to elicit concern from the SMCHD about restricted small-boat access to the inner harbor via the east entrance. Much of that sand probably comes down Denniston and Deer Creeks, some might come from erosion of the Princeton shoreline, and some seems to have been placed there for equipment staging during breakwater construction (Figure 8). Pre-breakwater, sand would have moved alongshore to the south. It is also possible that some of the sand in the delta comes from the south, being driven through the breakwater during large storms. Once inside the harbor, there is insufficient wave energy to move the sand back through the breakwater and into the littoral system. The importance of sand transport through the breakwater needs to be evaluated before a management plan for the interior sand can be properly implemented.

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[4] Calculation is based on data from the1998 Spring West Coast Post-El Niño LIDAR flights. NAVD88, which is the same as MLLW in the area (MLLW is -0.08 ft higher), is the datum. Flight time was not given, so tidal level cannot be included.

Figure 7: East end of Pillar Point Harbor showing the East Breakwater, inner breakwaters, and inner sand wedge adjacent to the root of the East Breakwater.

Figure 8: Sediment wedge inside the East Breakwater December 1959 (SPN archives).

Construction of the East Breakwater disrupted the equilibrium wave pattern and focused wave energy at the low cliffs south of the breakwater causing rapid cliff erosion along the shoreline in area of this project (Lajoie and Mathieson, 1985). Post-breakwater construction in that area, a county road was destroyed, state Highway 1 threatened, and the rate of sea cliff retreat increased from three inches per year to 80 inches per year (Figure 9 [Lajoie and Mathieson, 1985]). Specifically, by 1985 the sea cliff had eroded far enough into the terrace to destroy Mirada Road, which paralleled the cliff edge (Figure 10). The most likely causes of the increased erosion are shifting the center of the log-spiral to the south (Figure 11) and cutting off the sand supply from the north. Shifting the center of the spiral creates a different wave-energy dynamic along the length of Half Moon Bay as the shoreline tries to return to an equilibrium configuration. The greatest change will be where the spiral is the tightest, which is adjacent to the south side of the East Breakwater. The effect will taper off downcoast, and erosion will, consequently, be less. Because the net littoral transport is to the south, the combined impact of eliminating the sand supply from north of the project area and increasing the wave energy in that area will accelerate the erosion. As stated in USCE (1971):

> "The document that led to the law which set forth the details for the original construction of the breakwaters, contained a discussion of the effect of the proposed improvement on the shoreline. It was stated that maximum realignment of the shore would probably occur immediately south of the East Breakwater, which has been the case."

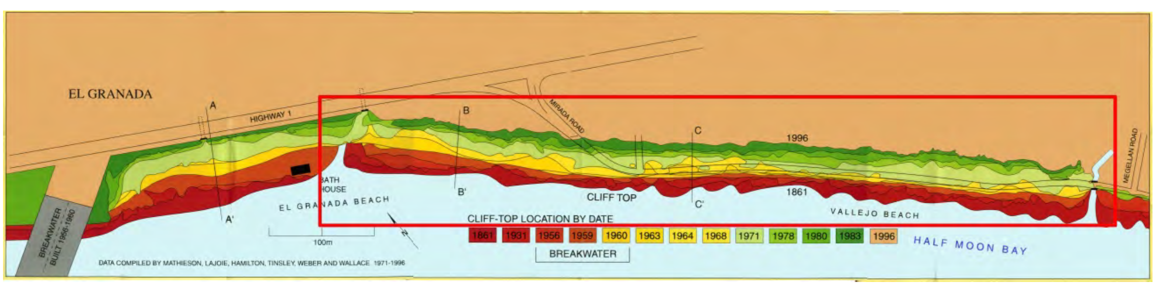

Figure 9: Cliff top retreat between 1861 and 1996 showing increased rate after construction of the Pillar Point breakwaters (Lajoie and Mathieson, USGS poster). Shoreline inside of the red box consists of a sandy beach fronting unprotected sea cliff. Shoreline to the north of the box has no beach at higher tides and the sea cliff is faced with a rubble-mound sea wall constructed by Caltrans to protect Highway 1. Shoreline to the south of the box (to Arroyo de en Medio, outside the figure) has no beach and the sea cliff is faced with a rubble-mound seawall to protect homes and businesses.

Figure 10: 1971 photograph of Mirada Road looking south from near the root of the East Breakwater. Riprap can be seen along the sea cliff starting at about the white house and going south. Photograph by K. Lajoie, USGS.

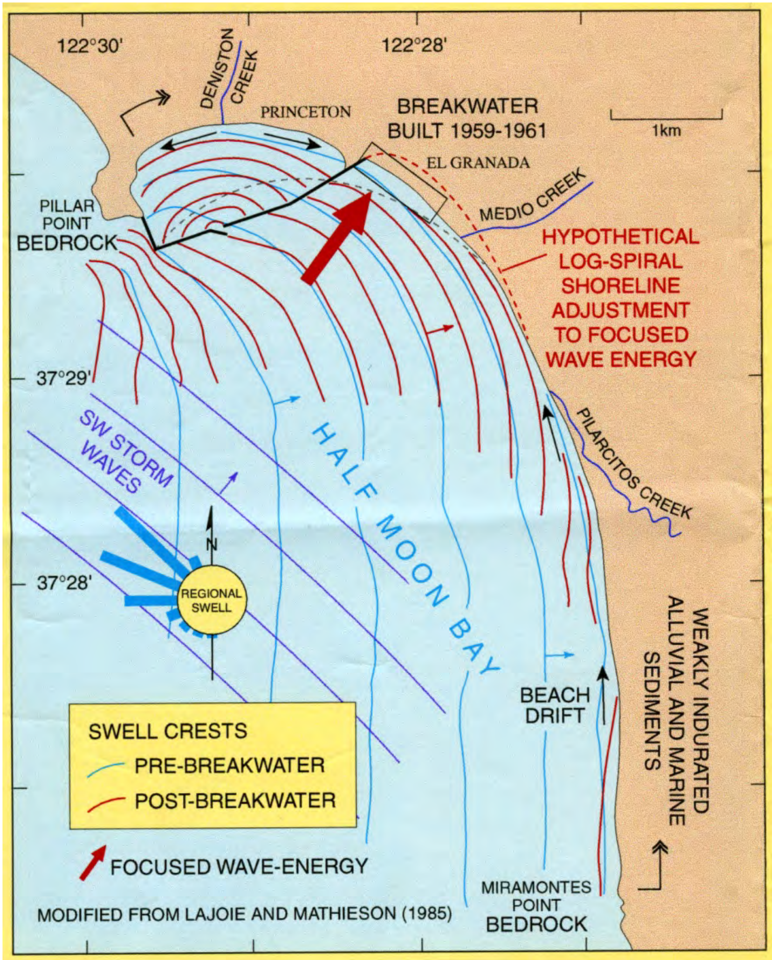

Figure 11: Hypothetical log-spiral shoreline adjustment to refocusing of the incident wave energy caused by the outer breakwaters (Lajoie and Mathieson, USGS poster). The project area stretches from the root of the East Breakwater to Medio Creek (Arroyo de en Medio).

This section discusses the formulation of alternatives for mitigating for future damages along the Half Moon Bay shoreline in the vicinity of the East Breakwater of Pillar Point Harbor. It sets forth the most environmentally sound, economically feasible, and socially beneficial alternative that does not result in environmental degradation. This section discusses problems, opportunities, restoration objectives, and constraints within the study. A series of restoration alternatives have been developed based on these problems, opportunities, objectives, and constraints.

5.1 Public Concerns

Input was received through coordination with the NFS, coordination with other agencies, public meetings, and individual discussions. The public concerns that are related to the establishment of planning objectives and planning constraints are:

- Besides being a safe refuge for private and commercial water craft during storms, Pillar Point Harbor is heavily used by commercial fishermen and recreational boaters, especially during salmon fishing season. Continued sand deposition next to the East Breakwater will reduce anchorage for small boats, decrease the accessibility of the inner harbor through its eastern entrance, and delay or deter user access to nearby open-ocean fishing sites.
- The aerial extent of recreational beach continues to decrease, especially in front of the revetments at Surfer's and Miramar Beaches. In fact, during much of a tidal cycle there is no beach in those locations. During such times, casual beach goers are precluded from using the area, and surfers must ingress and egress over rocks against which waves can be breaking or swash sweeping up and down.
- Besides making access more difficult, the lack of beach changes the dynamics of the nearshore wave environment. Wave energy that would be dissipated by wave swash over the sand is reflected seaward, which changes – by and large degrades – the incoming waves making them harder for surfers to catch and rides shorter and rougher. Because the area is often used by beginning surfers, including school-aged people taking lessons, such conditions reduce their enjoyment and increase the difficulty of learning to surf. The potential for injury on the rocks also increases, undoubtedly more for inexperienced surfers focusing on learning the techniques and not the setting.
- Where the coastal bluff is exposed to direct wave attack – the south end of Surfer's Beach and the entirety of Vallejo Beach – wave-caused bluff retreat presently threatens both the

shoulder of the south-bound lane of Highway 1 and the Coastal Trail where it crosses the coastal terrace. Because the Coastal Trail runs along that shoulder next to the revetment, the safety of trail users is more-and-more compromised with time.

- During many storms, waves break against the revetments throwing water and sand onto the adjacent roadways. This is especially a problem at Miramar Beach where Mirada Road can become awash, precluding safe use of the road.
- The bluff at the south end of the revetment at Miramar Beach is vulnerable to wave attack during large storms. Continued erosion in that area could damage or destroy roadway and the foot and bicycle bridge at the mouth of Arroyo de en Medio.

5.2 Problems and Opportunities

A major responsibility in the USACE planning process is to identify and categorize problems associated with the study area and opportunities that may address the identified problems through water- and related land-resource management. The final plan will depend on the agreement of the involved parties, costs and benefits, public concerns, funds, availability of necessary equipment, and physical processes that will act on the material after placement.

5.2.1 Problems

The following problems have been identified in the project area:

- If no action is taken, infilling of the harbor will continue increasing the difficulty of anchoring, accessing the inner harbor, and using the boat ramp.
- Ongoing erosion has limited public access, decreased recreational opportunities, and created hazards to the public – including surfers, fishermen, and beach joggers and walkers – to Surfer's and Miramar Beaches. If no action is taken, the amount of time there is exposed beach will continue to decrease until there the ocean impinges on the revetments during all stages of the tide, effectively ending beach use.
- Ongoing erosion has flanked the south end of the Surfer's Beach revetment, threatening Highway 1 and the Coastal Trail. If no action is taken, the shoulder and south-bound lane of the highway could fail, and trail users forced to walk in the highway or on the riprap.
- If no action is taken, sea level rise and more intense storms will further restrict access to the businesses and private homes along Mirada Road.

5.2.2 Opportunities

The following opportunities have been identified:

- Removing sand from inside the harbor – next to the East Breakwater – will improve maneuverability and anchorage in the harbor.
- Placing sand on or behind the beach will help restore a recreational beach and improve surfing.
- Placing sand in front of the coastal bluff will help protect Highway 1 and the Coastal Trail.
- Placing sand where longshore transport will carry it in front of Mirada Road will prevent or mitigate future damages to the roadway, businesses, and private structures.

5.3 Alternatives

Based on the suite of problems and opportunities, seven alternatives were evaluated. These alternatives were formulated with significant input from USACE's coastal engineering section, USACE project team members, and the public[5]. One alternative was selected, and its proposed action carried forward for detailed analysis in comparison with the No-Action Alternative. The other six alternatives were eliminated because they were either found to have a large impact on waters of the US, did not meet the project purpose, or were infeasible in terms of constructability or cost. Those alternatives included a wide array of structural and non-structural actions including beach fill, dredging, alteration of the East Breakwater, construction of a spur breakwater, and managed retreat.

5.3.1 No-Action Alternative (Without Project Conditions)

The USACE is required to consider the option of "No Action" as one of the alternatives to comply with the requirements of the National Environmental Policy Act (NEPA). No Action assumes that no project would be implemented by USACE to achieve planning objectives. No Action, which is also referred to as the "Without Project Conditions", forms the basis from which all other alternative plans are measured. The No-Action alternative characterizes current and anticipated future conditions at the project site in the absence of the proposed action to address

[5] Public meetings that were held on June 5, 2011, January 8, 2013, and November 8, 2013 provided a forum for the USACE PDT and the public to exchange ideas on potential alternatives.

beach and bluff erosion. Under the No-Action plan, USACE would not implement mitigation efforts for bluff or beach erosion in the vicinity of the East Breakwater at Pillar Point Harbor.

The USACE has analyzed recent bluff and beach erosion rates at the site and considered the potential impacts of "low", "intermediate" and "high" sea level change on these rates over the next 50 years. These analyses suggest that higher-than-expected rates of bluff erosion are present along Vallejo Beach (no bluff erosion is possible at Surfer's and Miramar Beaches because of the revetments) while sand is accreting in Pillar Point Harbor adjacent to the East Breakwater. Inside the harbor, sand would continue to accumulate along the inside of the East Breakwater and in the vicinity of the public boat ramp. Outside the harbor, the percentage of time there was a viable beach in front of the two revetments would continue to decrease and the exposed bluff at Vallejo Beach would continue to erode. Unabated, this erosion and accretion will result in loss of recreational opportunities as well as threats to public safety along Highway 1 and navigational safety in Pillar Point Harbor.

The results of the current bluff erosion analysis indicate that the bluff between the Highway 1 revetment and Mirada Road revetment retreated at a rate of 1.6 ft/yr from 1993 to 2012. This is significantly greater than the background rate of erosion as measured at a geologically similar section of shoreline further down the coast, which was on the order of 0.2 ft/yr. The accelerated erosion rate, however, does not appear to extend south of Miramar Beach, because the analysis showed a slow bluff retreat rate to the south of the revetment there. Similarly, a high rate of net beach erosion (4,200 yd^3/yr) along and offshore of the coast, which extended from the East Breakwater to the southern end of the Mirada Road revetment, was accompanied by a notable accumulation of sand within Pillar Point Harbor (approximately 2,000 yd^3/yr). Increases in sea level to intermediate or high levels would cause the water surface in the region to rise by 0.7 ft or 2.1 ft, respectively, in the study area over the course of 50 years. Under such conditions, rates of erosion of beach sand and adjacent bluffs as well as accretion of sand in the harbor would increase as the higher water levels expose the upper beach and bluff toes to more wave attack and carry more sediment into the harbor.

Under the No-Action alternative, the high rates of beach and bluff erosion along the coastline would continue unabated wherever there is not a revetment, and accretion of sediment within Pillar Point Harbor adjacent to the East Breakwater would continue. Extrapolating the current bluff erosion rates into the future, an approximately 80-ft-long section of the southbound shoulder of Highway 1 would be undermined within 10 years, and approximately 250 ft would be at risk in 50 years. This would create significant impacts to public safety and likely require relocating a portion of the highway, which would be expensive and could cause significant environmental impacts. Continued beach and bluff erosion would also continue to threaten recreational uses in the area. Beach erosion would result in loss of recreational beach area at Surfer's and Vallejo Beaches, while sections of the pedestrian Coastal Trail would likely be lost given that a section of the pathway at the north end of the Mirada Road revetment is already being actively undermined by wave-driven bluff erosion. Conversely, continued accretion of sediment in Pillar Point Harbor would increase the size of the existing shoal, posing an increasingly significant navigational risk of ship damage or stranding. These impacts could occur more quickly with a higher-than-forecast rate of sea level change.

5.3.2 Proposed Action (Agency-Preferred Alternative)

The proposed action would involve a one-time dredging of approximately 140,000 to 150,000 yd^3 of sand accumulated along the East Breakwater and placement of that sand to form a 125-foot wide elevated berm along the approximately 3,100-foot long section of shoreline that makes up Surfer's and Vallejo Beaches (Figure 12). This action would satisfy the project purpose of mitigating near-term beach and bluff erosion by providing a buffer that would reduce the erosional impacts of elevated water levels and wave attack in the placement area. Additionally, the proposed action would take advantage of the opportunity to remove excess shoaled sediment along the East Breakwater within the harbor, reducing a navigation hazard posed to vessels using the harbor's small boat launch ramp.

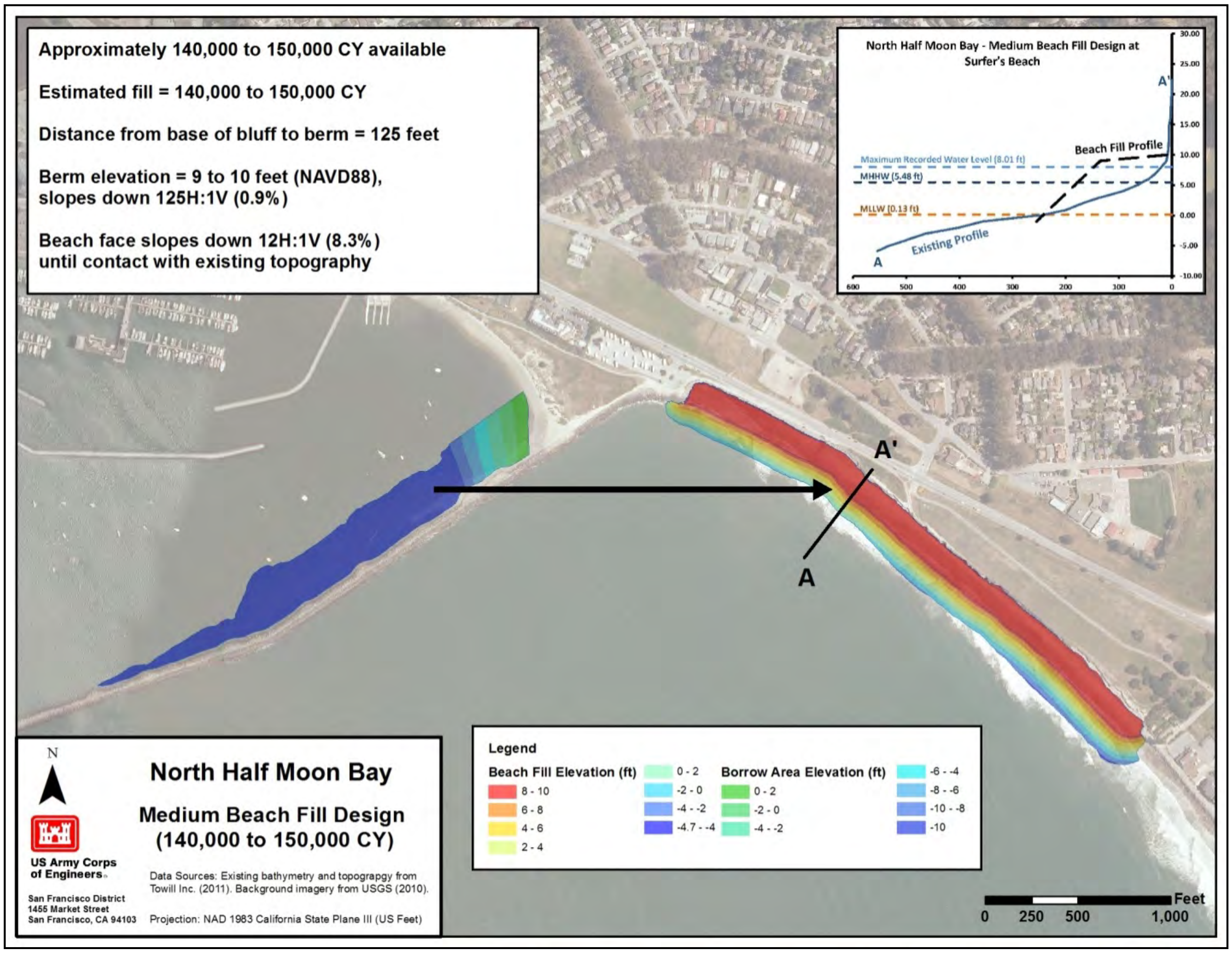

Figure 12: Plan view and representative cross-section of the Proposed Action Design that consists of a borrow area along the East Breakwater and a placement area along Surfer's and Vallejo Beaches.

The extensive sand shoal that has formed on the north side of the East Breakwater would serve as the exclusive source of sand for this proposed action. The sand would be dredged down to a depth of 10 ft (NAVD88), which would approximately match the surrounding bathymetry, and then pumped onto the adjacent back beach south of the breakwater. This analysis assumes a pipeline dredge would be used to remove and then pump the sand. The proposed action assumes that there will be no future additional sand placement. Sand placement is anticipated to be most effective in reducing the erosion of the unprotected bluff and in creating a beach in the immediate vicinity of the East Breakwater. Thus, sand placement would extend along the approximately 3,100-ft section of shoreline from the root of the East Breakwater to the north end of Miramar Beach. Over time, however, coastal processes would transport sand to the south, widening the beach in front of the revetment at Miramar Beach.

The engineering analysis predicts that approximately 10 to 15% of the sand would erode within one year with the majority of this sand moving seaward to the adjacent nearshore zone. A simple linear extrapolation of this erosion rate (24,000 yd^3/yr) would yield a lifespan of approximately 6 years for this (mostly) visible fill placement. It is anticipated, however, that this erosion rate will decrease after an initial period of adjustment to ambient hydrodynamic conditions, so the expected lifespan of the visible placement is likely longer than 6 years. In addition, the total residence time of the placed sand in the project area could be on the order of 30 to 40 years, given the net erosion rate of 4,000 yd^3/yr in the vicinity of the beach fill placement.

To minimize potential impacts to the nearshore zone and recreation activities like surfing, the proposed action maximizes the amount of fill placed on the sub-aerial beach (the part of the beach uncovered by water). The sand would initially be placed in an "over-built" berm shape. This analysis assumes the berm would be shaped with equipment including a small lightweight dozer and low ground-pressure scraper. Existing profiles in the proposed fill area show a steep upper beach with no natural berm or defined backshore beach. Profiles from a nearby beach suggest that a "natural" beach berm tends to form at an elevation of 15 ft (NAVD88) in this region. For the proposed action, a target berm elevation of 9 to 10 ft was selected, based on the highest recorded water level in the region (8.0 ft) and the elevation of the toe of the bluff backing the beach (10.0 ft). Given the available fill quantity (140,000–150,000 CY), the berm would be approximately 125 ft wide with a beach face that will slope down at 1V:12H (i.e., Vertical:Horizontal), until it contacts the existing nearshore seabed. The berm is expected to narrow overtime as the new beach profile approaches equilibrium with existing hydrodynamic conditions.

5.3.3 Alternatives Considered but Eliminated

1. *Maximum Beach Fill Alternative:* This alternative is nearly identical to the Proposed Action (§5.3.2) but would have involved a one-time dredging of approximately 200,000 to 250,000 yd^3 of sand from inside Pillar Point Harbor and placing that along the shoreline at Surfer's and Vallejo Beaches to create a 180-foot wide berm. This alternative would satisfy the project purpose of nourishing the beach to mitigate near-term beach and bluff erosion and would reduce the navigation hazard posed to vessels using the harbor's small boat launch ramp. It would have a larger 404(b)(1) impact on waters of the U.S. (in terms of acreage and cubic yards), however, and would remove coastal-strand habitat inside the harbor. Consequently, this alternative was eliminated from further consideration (see Environmental Assessment).

2. *Sealing the East Breakwater:* This alternative involved sealing a 2,500-ft section of the East Breakwater with concrete to prevent sand from surging through voids in the breakwater. Modeling of erosion and accretion patterns under this alternative suggested that while it would decrease accretion of sediment within the harbor, it was not likely to reduce beach and bluff erosion along Surfer's and Vallejo Beaches. This alternative was eliminated from further consideration because it would not meet the project purpose of nourishing the shoreline to mitigate beach and bluff erosion.
3. *Creating a Notch in the East Breakwater:* This alternative involved removing a short (~200-ft long) section of the East Breakwater to allow currents to move sand from inside the harbor to just offshore of the adjacent shoreline outside the harbor. Modeling of erosion and accretion patterns under this alternative suggested that while it would result in the release of a small quantity of sand from the harbor, it would not be enough to mitigate near-term erosion concerns at Surfer's and Vallejo Beaches. Additionally, the opening of a notch could alter hydrodynamic conditions inside the harbor in a way that would potentially create navigation hazards from larger waves entering the harbor and damaging vessels. This alternative was eliminated because it would not meet the project purpose of nourishing the shoreline to mitigate beach and bluff erosion.
4. *Alternative Dredged Material Placement*: This alternative involved the continuous removal of sand from the shoal along the harbor side of East Breakwater and placing that sand near the harbor entrance where it could move shoreward. Modeling of the potential sediment transport from this location suggests that most of this sand would be transported to relatively deep (~30 ft) water directly offshore of the entrance where it would settle and not provide shoreline erosion mitigation benefits for the project beaches. This alternative was eliminated because it would not meet the project purpose of nourishing the shoreline to mitigate beach and bluff erosion.
5. *Spur Breakwater:* This alternative involved constructing a 500- to 600-ft spur (deflector-arm) breakwater in conjunction with placement of 230,000 yd^3 of fill in the nearshore zone. The spur would extend southeast from the existing East Breakwater, oriented parallel to the shoreline, to reduce wave energy and induce accretion of the placed sediment. The cost of the spur breakwater was estimated by USACE in 1971 and 2006 to be on the order of $2.5-3.2 million and placement of this quantity of sand would cost approximately $6.4 million for a total cost of $8.9-9.6 million for this alternative. Because with inflation the cost of this alternative could exceed the CAP §111 limit ($10M) and because construction would have

significant environmental impacts, this alternative was eliminated from further consideration.

6. *Managed Retreat:* This alternative involved accommodation of future erosion of the unprotected marine terrace (bluff) backing Surfer's and Vallejo Beaches. This alternative assumed only the infrastructure that is not currently protected by well-maintained revetments would need to be relocated. Based on extrapolation of current bluff erosion rates, a portion of Highway 1 as well as part of the pedestrian coastal trail would need to be relocated. Although detailed plans for relocation have not been developed, based on the cost per linear foot of comparable relocation of the Great Highway at Ocean Beach in San Francisco, the cost of relocating a 4,400-ft section of Highway 1 would be approximately $16 million. Because this alternative would not meet the project purpose of nourishing the shoreline to mitigate beach and bluff erosion and cost exceeded the CAP §111 limit, it was eliminated from further consideration.

5.3.4 Suggested but not Evaluated Alternatives

Other alternatives were briefly discussed by the PDT. These were dismissed out of hand because they were beyond the level and scope for a CAP §111 project or did not meet project objectives or both.

- Construct groins to retain sand dredged from the harbor and placed on Surfer's and Vallejo Beaches
- Modify the shape of the East Breakwater to create a different wave-energy focus
- Remove the East Breakwater
- Replace the revetments with cobble beaches
- Reroute and daylight Deer Creek to enter the ocean south of the East Breakwater
- Create a submerged sand berm in shallow water offshore of the stretch of beach in the project area
- Dredge sediment from inside the harbor and place it upland
- Remove the revetments
- Allow shoreline retreat from Surfer's Beach to the Miramar revetment
- Purchase and remove development to allow for shoreline retreat
- Relocate Highway 1 inland or transform it into a causeway

The environmental conditions discussed in this section are only the conditions that are necessary for formulation or are necessary for design and construction considerations. The Environmental Assessment (EA) has a more thorough discussion of the Environmental Conditions for this project.

6.1 Summary of indirect and cumulative effects from the proposed action

The proposed action (§5.3.2) would not have significant adverse indirect or cumulative impacts on the physical, biological, and human environment. Temporary and minor direct adverse effects associated with the proposed action are expected to be short in duration and would end upon completion of construction. They would be less than significant given the assumed avoidance measures and BMPs described in the Environmental Assessment (Environmental Appendix). Long-term impacts of the proposed action would be beneficial in terms of minimizing erosion, removing navigational hazards, and improving recreation and habitat at the project site.

6.2 Aquatic Habitat and Organisms

The project area contains both intertidal and subtidal aquatic habitats and common species supported by those habitats.

6.2.1 Intertidal Zone

The intertidal zone, which lies between MLLW and mean higher high water (MHHW), is alternately exposed during low tides and inundated during high tides. The project area includes both sandy and rocky intertidal zones. The majority of the intertidal habitat in the project area is sandy and includes the shore within Pillar Point Harbor between the boat launch and the East Breakwater; the inner and outer flanks of the East Breakwater; and the shore along Surfer's, Vallejo, and Miramar Beaches.

6.2.2 Subtidal Zone

The subtidal zone, which lies below MLLW, is covered by water except during minus tides. Subtidal habitat in the project area includes the open-water area inside of Pillar Point Harbor where dredging is proposed to take place, the submerged portion of the East Breakwater abutting the proposed dredging area, and the nearshore zone seaward of the MLLW line along the outer coast beaches within the project area. Unconsolidated sediment (sand or mud) with some areas of hard bottom or nearshore rocky outcrops comprise the sea floor in the subtidal zone (CSMW, 2015). The nearshore zone is relatively shallow, and high-energy waves and currents interact with the sandy bottom causing coarser sediments to settle closer to shore. Because the deeper areas of the subtidal zone experience less wave action, they are characterized by fine sand and sediment with a significant amount of mud.

6.2.3 Aquatic Organisms

The aquatic habitats in the action area support numerous invertebrates, fish, and marine mammals. The sandy intertidal environment provide important habitat for various organisms living under the surface of the sand – e.g., clams, crabs, and other invertebrates – and also serves as an important feeding ground for shore birds (CSMW, 2015). Rocky intertidal habitat is capable of supporting many species, including sessile invertebrates such as mussels, barnacles and anemones and mobile grazers and predators such as crabs, amphipods, littorine snails, limpets, sea stars, sea urchins, and abalone (CSMW, 2015). Tidepool fish including striped surfperch, tidepool sculpin, tidepool snailfish, and cabezon may also occupy this habitat. Vegetation growing on the intertidal rocks of the East Breakwater include species of algae such as sea lettuce (*Ulva sp.*), lichens, plantain (*Plantago maritime*), and bristly ox tongue (*Picris echioides L*).

The nearshore subtidal zone, which experiences high wave energy, is generally occupied by small, mobile, deposit-feeding crustaceans and contains fewer species of invertebrates than in the finer sandy to mixed sediments offshore (CSMW, 2015). Benthic subtidal habitat in the region is occupied by invertebrates such as polychaete worms (including *Mediomastus californiensis* and *Polydora kempi*), anemones, shrimp (*Neomysis rayii, Bathyleberis sp.*, and *Euphilomedes carcharodonta*), crabs (including *Hemigrapsus nudus*), bivalves (including *Macoma secta* and *Transennella tantilla*), Seastars (including *Amphiodia sp.*), and gammarid amphipods (including *Aoroides columbiae* and *Corophium acherusicum*), among other sessile and suspension feeding organisms (USACE, 2006). Subtidal waters provide foraging and summer nursery habitat for fish such as English sole (*Parophrys vetulus*), shiner surfperch (*Cymatogaster aggregate*), Pacific herring (*Clupea harengus*), and rockfish (*Sebastes sp.*) (California Coastal Commission, 1999). Starry flounder (*Platichthys stellatus*) and topsmelt are abundant in winter when northern anchovy (*Engraulis mordax*), Pacific sardine, mackerel, and striped bass are also present (California Coastal Commission, 1999). Marine birds also feed in this habitat. While kelp beds, an important type of submerged aquatic vegetation (SAV), have been documented growing in subtidal habitat in Half Moon Bay, no kelp beds are present in Pillar Point Harbor or close to the project beaches.

The harbor seal (*Phoca vitulina*) is the most common marine mammal at Pillar Point. Those seals forage near the shore, in water that is up to 16 feet deep, and rest on the breakwater. This stretch of coast provides numerous haul-out sites for harbor seals and California sea lions, and marine protected areas north of the harbor are breeding areas for harbor seals. Several species of whales and porpoises are also found offshore (including gray whale (*Eschrichtius robustus*), humpback whale (*Megaptera novaeangliae*), blue whale (*Balaenoptera musculus*), and harbor porpoise (*Phocoena phocoena*). Those are likely to occur in the nearshore project action areas (CSMW, 2015; USACE, 2006).

6.3 Terrestrial Habitat

Terrestrial habitat in the project area includes sandy beach, coastal strand, coastal terrace with bluff, and man-made surface areas.

6.3.1 Sandy Beach

The majority of the terrestrial environment in the proposed action area is sandy beach habitat that includes dry backshore areas as well as the intertidal foreshore between MHHW and MLLW (the intertidal zone is discussed in §Error! Reference source not found.). The sandy backshore is characterized by lower productivity than the adjacent intertidal habitat but provides primary habitat for a variety of species. This habitat can also support a variety of recreational values, including sunbathing, wading, surfing, swimming, recreational clamming, and fishing (CSMW, 2015). Sandy beach habitat in the project area is located along Surfer's, Vallejo, and Miramar Beaches and along the inner shore of Pillar Point Harbor between the East Breakwater and the boat launch ramp.

6.3.2 Coastal Strand

Coastal strand habitat is characterized by vegetation that grows on beach backshore or foredune areas. This vegetation is adapted to areas affected by strong winds, waves, and salt spray. Native coastal strand habitat is considered rare in California and non-native vegetation often outcompetes and reduces the native plant diversity in coastal strands. Strands are particularly vulnerable to human impact, including beach recreation, beach grooming, development, and hardened shoreline protection (CSMW, 2015). Coastal strand habitat at the project site is located in a fenced off area just inside Pillar Point Harbor in the sandy backbeach near the base of the East Breakwater (Figure 7).

6.3.3 Rocky Habitat

Rocky terrestrial habitat in the project area includes the rocks on the top and inside of the East Breakwater that are high enough to remain dry even when the tide comes in.

6.3.4 Terrestrial Organisms

Sandy beach habitat supports species of invertebrates (described under aquatic organisms for intertidal zone); provides forage, resting, and nesting habitat for birds (described under aquatic organisms above); and spawning habitat for California grunion, which spawn between March and September (CSMW, 2015). Long-tailed weasel (*Mustela frenata)*, broad-handed mole (*Scapanus latimanus),* and California meadow vole (*Microtus californicus)* may also inhabit this habitat. Costal strand habitat at the project site supports a variety of vegetation such beach bur (*Ambrosia chamissonis),* gumweed (*Grindelia Willd.)*, sealavender (*Limonium P. Mill).,* and wild radish (*raphanus sativa),* as well as non-native plants like iceplant (*Carpobrotus chilensis)* and sea rocket (*Cakile maritime).* Terrestrial inhabitants of the rocky habitat along the East Breakwater may include common pill bugs (*A. vulgare)* and crabs and birds (described in §Error! Reference source not found.) resting on the rocks. Marine mammals such as harbor seals may rest on the rocky breakwaters and could potentially haul out on the sandy beaches in the project area.

6.4 Threatened and Endangered Species

This section focuses on species and habitats regulated under the state and federal Endangered Species Acts (ESA), the Magnuson-Stevens Fisheries Conservation and Management Act (MSFCMA), the Marine Mammal Protection Act (MMPA), and the Migratory Bird Treaty Act (MBTA).

6.4.1 Endangered Species act

The USACE conducted a preliminary review to investigate the potential presence of listed, proposed, and candidate species and their critical habitats within the project action area. The resulting list was refined to identify only those species that could reasonably be expected to occur in the project action area given its habitat constraints and the species' known ranges and life histories (Table 4). Listed species and critical habitats that were found to reasonably have the potential to occur in the project action area are discussed further below. Error! Reference source not found. illustrates designated critical habitats in the project region.

Table 4: Listed species With the Potential to Occur in the Proposed Action Area

COMMON NAME	SCIENTIFIC NAME	FEDERAL[1]	STATE[1]	POTENTIAL FOR PRESENCE WITHIN THE PROJECT VICINITY
				Fish
Southern DPS green sturgeon	*Acipenser medirostris*	FT, CH	SSC	Found in nearshore waters. CH includes all coastal marine waters, bays, and estuaries from Vancouver Island, British Columbia to Monterey Bay, California.
Central California Coast coho salmon ESU	*Oncorhynchus kisutch*	FE, CH	SE	Found in coastal waters, estuaries, and freshwater streams. CH includes all water, substrate and adjacent riparian zones of all accessible river reaches and estuarine habitat from Punta Gorda in northern California to the San Lorenzo River, which empties into Monterey Bay at Santa Cruz.
Central California coastal steelhead ESU	*Oncorhynchus mykiss*	FT, CH	--	Found in coastal waters, estuaries, and freshwater streams. CH includes many accessible river reaches and estuarine areas from the Russian River to Aptos Creek in Monterey Bay (inclusive). Denniston Creek which drains into Pillar Point Harbor 1km north of the project site is designated as critical habitat.
South Central California coastal steelhead ESU	*Oncorhynchus mykiss*	FT, CH	--	Found in coastal waters, estuaries, and freshwater streams.. CH includes all accessible river reaches and coastal river basins from the Pajaro River (inclusive), Santa Cruz County, south to the Santa Maria River.
				Marine Invertebrates
Black abalone	*Halitoes cracherodii*	FE, CH	--	A portion of the project action area falls within designated Black abalone critical habitat.
				Marine Reptiles
Leatherback sea turtle	*Dermochelys coriacea*	FE, CH	--	Critical habitat includes the California Coast from Point Arena to Point Arguello. The project action area falls within this critical habitat and the species has been spotted off the coast by recreational tour groups.
Green turtle	*Chelonia mydas*	FT	--	Have been sighted from Baja California to southern Alaska but most commonly occur from San Diego south.
Loggerhead sea turtle	*Caretta caretta*	FT	--	Individuals reported as far north as Alaska and as far south as Chile, with numerous records off the coast of California.
				Marine Mammals
Southern sea otter	*Enhydra lutris nereis*	FT	FP	current range is from Half Moon Bay, San Mateo County, south to Point Conception, Santa Barbara County. Sea otters have been observed in Pillar Point Harbor previously.

Common Name	Scientific Name	Federal[1]	State[1]	Potential for Presence Within The Project Vicinity
		Birds		
Western snowy plover	*Charadrius alexandrines nivosus*	FT, CH	--	Critical habitat is present at Half Moon Bay State Beach south of the proposed action area.
Marbled murrelet	Brachyramphus marmoratus	FT, CH	E	Critical habitat is present in Half Moon Bay.
California brown pelican	*Pelecanus occidentalis californicus*	Delisted	FP	This species has been observed within Pillar Point Harbor.

[1]FT= Federal Threatened; FE= Federal Endangered; CH= Critical Habitat; ST= State Threatened; SE= State Endangered; SSC= State Species of Special Concern; FP= State Fully Protected.

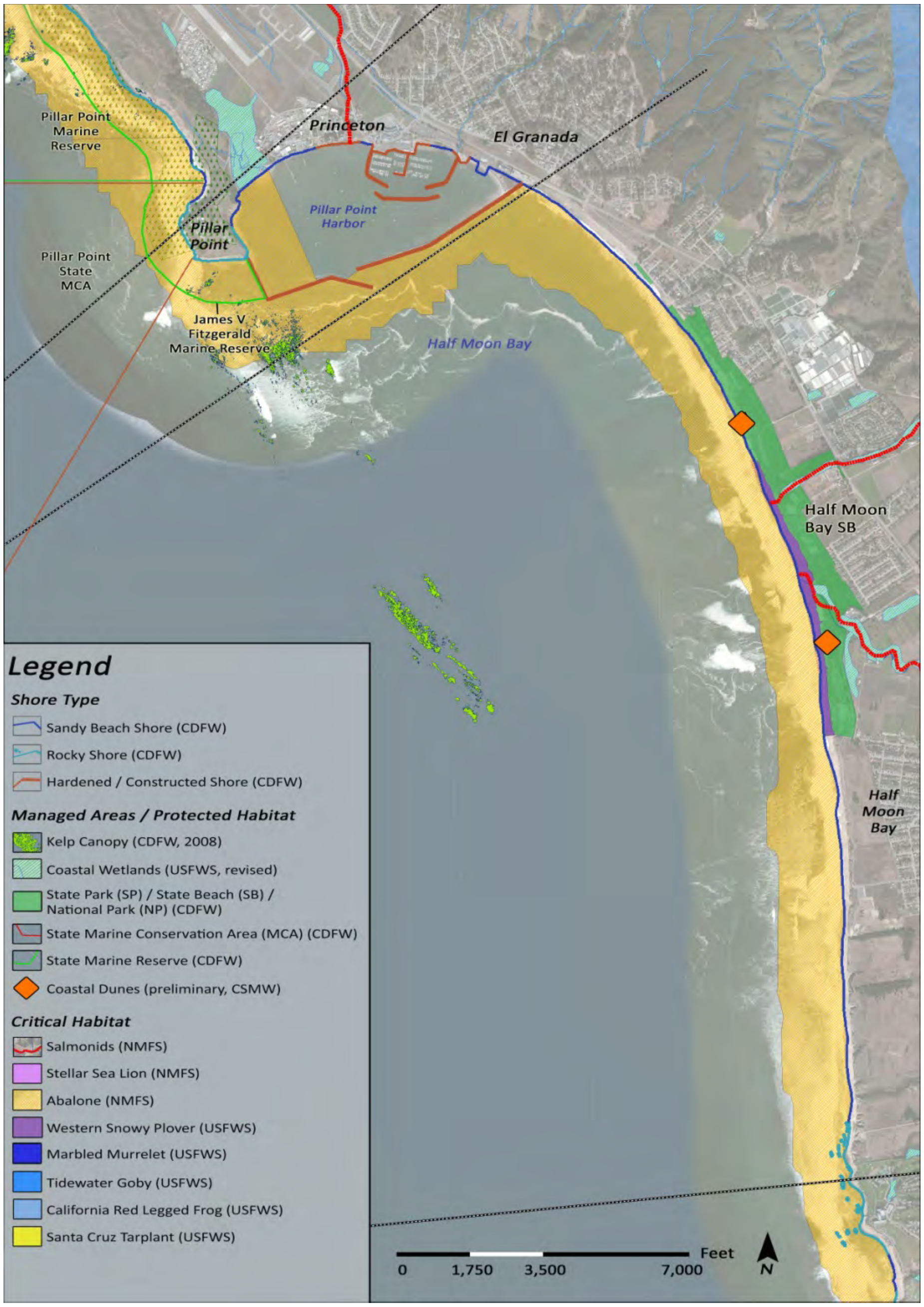

Figure 13: Critical Habitat in the Proposed Project Region.

6.4.2 Essential Fish Habitat (EFH)

Essential Fish Habitat is defined under the MSFCMA as waters and substrate necessary for spawning, breeding, feeding, or growth to maturity for certain fish species. The central California coast region contains EFH designated for three Fishery Management Plans (FMPs): the Pacific Coast Salmon Plan, the Coastal Pelagics Plan, and Pacific Groundfish Management

Plan. Many of the species managed under these three plans are known to occur in the project region.

In compliance with the MSFMCA, an EFH assessment and consultation with NMFS regarding adverse effects to EFH from the proposed action would need to be conducted before the project is implemented to obtain EFH conservation recommendations to avoid, minimize, mitigate, or otherwise offset the potential adverse effects to EFH. If USACE determines that there is federal interest in the project and it will serve as the lead federal agency, USACE would conduct an EFH consultation with NMFS and implement resulting conservation recommendations.

Given the temporary, minor nature of the anticipated effects and with implementation of any EFH conservation recommendations provided by NMFS, no significant impacts to EFH would be expected from the proposed action. Under the No-action alternative, no impacts to EFH would occur.

6.4.3 Marine Mammal Protection Act

Marine mammals protected under the MMPA include species of pinnipeds (seals and sea lions), fissipeds (otters); and cetaceans (whales, dolphins, and porpoises). Protected marine mammals that may occur in the vicinity of the project action area include Pacific harbor seals (*Phoca vitulina*), northern elephant seals (*Mirounga angustirostris*), California sea lions (*Zalophus californianus*), stellar sea lions (*Euetopias jubatus*), and southern sea otters (*Enhydra lutris nereis*). Harbor seals are the most common marine mammal in Pillar Point Harbor.

Because of the temporary, minor nature of any potential noise and turbidity from a potential project, the availability of other high-quality habitat in the region of the project, the ability of marine mammals to avoid construction areas, and assuming implementing measures to avoid harassment, no impacts to protected marine mammals are expected from the proposed action, and none will occur under the no-action alternative.

6.4.4 Migratory Bird Treaty

Many species of birds are protected under the MBTA, which makes it illegal to "…pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess…at any time, or in any manner, any migratory bird…or any part, nest, or egg of such bird." (16 U.S.C. 703). Table 4 describes the bird species that commonly occur in the vicinity of Pillar Point Harbor and the potential for impacts to these species.

Based on the proposed avoidance measures and the assumption that any additional measures recommended by the USFWS would be implemented if feasible, no impacts to bird species protected under the MBTA are expected from a potential project.

6.5 Section 404 of the Clean Water Act

Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act [CWA]) requires USACE to analyze its activities that involve placement of dredged or fill material into waters of the United States (33 USC 1344). For both water-dependent and non-water-dependent projects, the Guidelines prohibit discharges of dredged or fill material into waters of the United States if a practicable alternative to the proposed project exists that would have less adverse impacts on the aquatic ecosystem, including wetlands, and does not have other significant environmental consequences (40 Code of Federal Regulations [CFR] 230 [a])

The basic project purpose, which comprises the fundamental, essential, or irreducible purpose of the proposed project, is used to determine whether the project is water dependent. Water dependency is defined as an activity requiring access, proximity to, or siting within a special aquatic site (as defined in 40 CFR 230.40- 230.45) to fulfill its basic project purpose. Special aquatic sites include (1) sanctuaries and refuges, (2) wetlands, (3) mud flats, (4) vegetated shallows, (5) coral reefs, and (6) riffle and pool complexes. The basic purpose for the proposed action is the prevention or mitigation of shoreline infrastructure economic damages via the proposed alternative which will also provide beach nourishment, which is considered a water-dependent activity given that the proposed action is located within the MBNMS, a special aquatic site.

6.6 Air Quality

The Pillar Point Harbor project area lies within the nine-county San Francisco Bay Area Air Basin (SFBAAB). The Bay Area Air Quality Management District (BAAQMD) regulates onshore (stationary) air pollution sources in the SFBAAB, including San Mateo County. Presently, BAAQMD is in "attainment" of all National Ambient Air Quality Standards (NAAQS) except the 8-hour ozone standard and the 24-hour particulate matter 2.5 micron ($PM_{2.5}$) (BAAQMD, 2015). The 1-hour carbon monoxide and particulate matter 10 micron (PM_{10}) standards are unclassified because of a lack of data for the EPA to form a basis on attainment status.

All emissions associated with the proposed project are from maintenance dredging to existing authorized depths and associated placement of material. In accordance with 40 CFR § 51.853(c)(2)(ix), requirements for preparation of conformity determination under the CAA do not apply to maintenance dredging and debris disposal where no new depths are required, applicable permits are secured, and placement will be at an approved site. This analysis assumes that all applicable permits for the project will be secured and the placement of material at Surfer's and Vallejo Beaches for nourishment will be approved. Therefore, the proposed dredging and placement activities are considered exempt from conformity determination requirements and in compliance with the CAA.

6.7 Noise

Ambient sources of noise in the vicinity of the project action area include Pillar Point Harbor vessel traffic and operations, recreation activities along Surfer's and Vallejo Beaches, breaking waves along the shoreline, air traffic from the Half Moon Bay Airport, and vehicular traffic noise from the adjacent Highway 1.

Noise levels associated with the proposed dredging and beach nourishment activities would be temporary and are not expected to significantly exceed ambient noise levels in the project area. Generally, noise levels above 70 dB produce the following human responses: 80 to 90 dB (annoying), 100 dB (very loud), 110 to 120 dB (extremely loud), 130 to 140 dB (painfully loud) (SAIC, 2007). Reported airborne noise levels of dredges range from 76 to 88 dBA at 50 ft (15 m) from the source while average noise levels during beach nourishment have been estimated to be around 85 to 90 dBA (SANDAG, 2000 as cited in SAIC, 2007). This analysis assumes the berm to be constructed from the placed material would be shaped with equipment including a small lightweight dozer and low ground pressure scraper. The Washington Department of Transportation (2006, as cited in SAIC 2007) suggests that the airborne noise associated with a bulldozer can range from 85 to 103 dB at 50 ft and that of a grader can range from 79 to 93 dB at 50 ft. Given these noise levels, both the proposed dredging and placement activities would remain at or below levels that could annoy people who are more than 50 feet from the activities. Noise levels would be lower at greater distances from the activities.

This analysis assumes that all construction equipment would be professionally maintained and fitted with standard manufacturers' mufflers and silencing devices. Additionally, construction activities would be scheduled to comply with City of Half Moon Bay noise ordinances that restrict construction hours to weekdays from 7:00 a.m. to 6:00 p.m., Saturdays

8:00 a.m. to 6:00 p.m., and Sundays 10:00 a.m. to 6:00 p.m. (City of Half Moon Bay, 2009). In light of these measures along with the relatively noisy ambient conditions at the project site and the temporary nature of the proposed construction activities, any potential increase in noise levels created by the proposed action is expected to be less than significant.

6.8 Transportation and traffic

State Highway 1, which runs along the coast adjacent to the project site, is a vital traffic artery. A paid parking area is located north of the root of the East Breakwater adjacent to the highway. Dredging activities associated with the proposed action are not expected to affect ground transportation or traffic volumes as the dredging vessel will access the project site from the ocean or bay. During project construction and implementation, heavy machinery will require staging and access to Surfer's and Vallejo Beaches. Worker vehicles will also make trips to and from the project site and require parking areas. Because the project is currently in the feasibility stage, construction activity details such as the location of staging areas and equipment access route to the beaches have not yet been identified. This analysis assumes a portion of the paid parking area would be temporarily used for construction equipment staging and worker vehicle parking because the area has been used for staging in the past (e.g., USACE, 2006). The remainder of the parking area, including the driveway that provides access to Highway 1, would remain open for public use. A minimal number of worker vehicle trips along Highway 1are anticipated in association with the proposed action and would be an insignificant addition to existing traffic levels on the highway. Therefore any effects on transportation and traffic from the proposed action would be minor, temporary, and less than significant.

The proposed action would also benefit transportation in the long term by providing added protection against erosion of the shoreline and material supporting Highway 1. The USACE projected current bluff erosion rates 10 and 50 years into the future and determined that infrastructure, such as Highway 1 and coastal pedestrian paths leading to the beach, would be significantly threatened without action (Figure 4). Although the California Department of Transportation (CalTrans) has placed some riprap to protect portions of the highway behind Surfer's beach and has plans to expand the protection to the south, the proposed action will also help protect the highway into the future thus benefiting transportation in the region.

6.9 Navigation

Pillar Point Harbor comprises an inner harbor and outer harbor. The inner harbor, which berths 180 commercial fishing vessels and approximately 200 recreational boats, is encompassed within the much larger outer harbor area. Between the inner harbor and the East Breakwater there is a small boat launch. The harbor is heavily used by recreational and small commercial vessels. These vessels often transit near or through the portion of the project area inside the outer harbor and adjacent to the East Breakwater. Safe navigation is maintained by well-marked channels and the presence and activity of various enforcement agencies (e.g., the U.S. Coast Guard).

The proposed action would involve dredging material shoaled along the East Breakwater inside the outer harbor and pumping that material via hydraulic pipeline over the East Breakwater to the back beach. The presence of the dredge vessel in the project action area would temporarily increase vessel traffic in the harbor but is unlikely to significantly interfere with navigation in the harbor. The dredging area is located in the far-southeast corner of the harbor, and the dredge would not block access for vessels traveling between the open ocean, outer harbor, and inner harbor. Similarly, the dredge is not expected to prevent normal usage of the small boat launch. Dredge operators would follow all navigational procedures required inside the harbor to ensure continued navigational safety. No adverse effects on navigation are anticipated from the proposed action. Additionally, the proposed action would directly benefit navigation inside the harbor by removing the shoaled material along the East Breakwater that currently presents a navigation hazard for vessels transiting the area because they could run aground on the sandy shoal.

6.10 Coastal Zone Management Act

The proposed action falls within the jurisdiction of the California Coastal Commission (CCC), a state agency that implements the Coastal Zone Management Act (CZMA) with authority over coastal areas of the state. The CZMA requires that federal actions be consistent, to the maximum extent practicable, with federally approved state coastal plans. The federally approved state coastal plan applicable to the project location is the California Coastal Management Program (CCMP)[6]. The CCC's standard of review for federal Consistency

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[6] The California Coastal Management Program is a combination of federal, state, and local planning and regulatory authorities for controlling the uses of land, air, and water resources along the coast.

Determinations is the policies of Chapter 3 of the California Coastal Act of 1976, as amended, including applicable policies related to public access, recreation, the marine environment, land resources, development, and industrial development.

The project would not be implemented until concurrence from CCC on the determination is received. Therefore, the proposed action will not significantly conflict with the CCC's CZMA plans and policies.

6.11 Monterey Bay National Marine Sanctuary

The portion of the proposed action area outside of Pillar Point Harbor is regulated under the National Marine Sanctuaries Act (NMSA) because the area is located within the MBNMS. The MBNMS enforces thirteen federal regulatory prohibitions designed to preserve and protect the natural and cultural resources and qualities of the ocean and estuarine areas within its boundaries. Four of these prohibitions are potentially applicable to the proposed project:[7]

1. Drilling into, dredging, or otherwise altering the submerged lands of the sanctuary; or constructing, placing, or abandoning any structure, material, or other matter on or in the submerged lands of the sanctuary (with the exception of several activities, such as boat anchoring and harbor maintenance projects);
2. Discharging or depositing, from within or into the sanctuary, any material or other matter (with the exception of several activities, such as dredged material disposal at designated sites);
3. Discharging or depositing, from beyond the boundary of the sanctuary, any material or other matter that subsequently enters the sanctuary and injures a sanctuary resource or quality; and
4. Taking (disturbing or injuring) any marine mammal, sea turtle, or bird within or above the sanctuary, except as authorized by the MMPA, ESA, or MBTA (regardless of intent);

While dredging activities associated with the proposed action would occur in Pillar Point Harbor and thus outside the jurisdiction of the MBNMS, it could involve placement of material in the sanctuary (i.e. below the MHW mark). This type of action conflicts with the first two prohibitions listed above. Although the third prohibition addresses placement of material that may enter the sanctuary and harm or degrade resources, the material used for the proposed

[7] The included summary of prohibited actions was adapted from a summary included in USACE (2015).

beach nourishment action will be predominantly sand and tested to ensure it is safe for beach nourishment. Although it may enter the sanctuary, this process would mimic natural beach erosion and would not harm sanctuary resources. Therefore, the proposed action would comply with this regulation. The proposed action would also comply with the fourth prohibition through implementation of the avoidance measures assumed in this analysis and obtained through any necessary consultation with the USFWS and NMFS. These steps are expected to prevent associated taking of any marine mammal, sea turtle, or bird within or above the sanctuary, except as authorized by the MMPA, ESA, or MBTA.

Under the NMSA, the MBNMS has the ability to grant permits for prohibited activities, provided that the activities meet certain criteria such as having, at most, short-term and negligible adverse effects on sanctuary resources and qualities (15 CFR Section 922.133) (CSMW, 2015). Alternatively, authorizations may be issued under special circumstances for activities otherwise prohibited by MBNMS regulations if

- an activity has been authorized by a valid lease, permit, license, approval or other authorization issued after the effective date of MBNMS designation by any federal, state, or local authority;
- the Superintendent finds that the activity will not harm sanctuary resources and qualities; and
- the applicant complies with all applicable regulations and any specific conditions or terms specified by the Superintendent (CSMW, 2015).

Such an authorization may be issued in conjunction with a valid lease, permit, license, approval or other authorization issued by any federal, state, or local authority of competent jurisdiction (CSMW, 2015). For example, if a project requires a CCC permit (or another relevant permit issued by a state or federal agency), MBNMS staff could review and potentially authorize that permit. The CSMW (2015) also notes that the MBNMS Coastal Armoring Action Plan (activity 2.8) directs the sanctuary to pursue a pilot program to evaluate environmentally sound alternatives to coastal armoring (including beach nourishment), although the MBNMS Harbors and Dredge Disposal Action Plan (activity 5.1) directs the MBNMS to examine the potential beneficial use of dredged material in the sanctuary.

The USACE is actively coordinating with the MBNMS to evaluate potential mechanisms for carrying out the proposed project in light of the sanctuary prohibitions. The MBNMS served as a cooperating agency under NEPA (40 CFR §1501.6) in preparing this Integrated DPR and Draft

EA, lending its expertise in jurisdictional issues and the potential for effects to sanctuary resources related to the proposed action. On May 19, 2015, USACE and the MBNMS participated in a Beach Replenishment Committee Meeting hosted by the SMCHD to discuss the proposed action and alternatives. The MBNMS staff suggested that the project could potentially be carried forward by either limiting placement of material to outside the sanctuary boundaries (above MHW), which would not require a sanctuary permit, or by obtaining a permit and implementing the proposed action such that only dry material obtained by means other than dredging is placed in the sanctuary boundaries (i.e. below MHW) and any material dredged from within the harbor is placed outside of the sanctuary boundaries.

Given that USACE and the MBNMS are working together to determine acceptable ways to implement the proposed action in accordance with the policies of the sanctuary, the proposed project is not expected to have a significant conflict with sanctuary regulations. If it is determined that USACE has federal interest in the project and will serve as the lead federal agency, it will continue to coordinate with the MBNMS on the project. The USACE will obtain any permits or authorizations necessary to implement the project and will comply with any specific conditions or terms specified by the MBNMS.

The primary purpose of this Economic Analysis is a benefit-cost analysis for one or more project alternatives that considers total NED benefits and total NED costs. That purpose will be attained by a) describing and estimating the expected future economic damages along the shoreline that are attributable to the existence of the federal East Breakwater at Pillar Point Harbor and b) estimating the economic benefits of potential measures that could be implemented to mitigate for the adverse impacts caused by the breakwater.

7.1 Guidance and References

The approach taken by this Economic Analysis is in accordance with current principles and guidelines and standard economic practices, as outlined in the Planning Guidance Notebook (PGN) – ER 1105-2-100, as well as the Institute for Water Resources (IWR) Report 2011-R-09, *Coastal Storm Risk Management National Economic Development Manual*. The base year (the first year in which a project could be implemented) is assumed to be 2017. All discounting is done using the 2015 federal water resources discount rate of 3.375%. For reasons that are described in the report, a 20-year period of analysis was chosen. Guidance and procedures for estimating recreation value came from USACE Economic Guidance Memorandum (EGM) 15-03 and the PGN.

7.2 NED Impacts Categories

An NED analysis considers all NED benefits and costs wherever they occur. Therefore, to the extent there are economic effects other than those specifically intended, they must be identified and taken into account. As an example, if shore protection has a negative impact on recreation use or adverse impacts to the shoreline outside the study area, this impact must be considered and displayed. Importantly, NED focuses on the efficiency gain that is produced for the Nation as a whole and not on transfers from one U.S. region to another. A project may be economically attractive from a regional perspective but unwise from a national perspective. In contrast, if a study area is not large enough, problems or projects may affect other areas many miles away. This project could be highly attractive from the NED perspective, but may not look as attractive regionally to the NFS, community, other stakeholders, and other government agencies.

The NED costs are the opportunity costs of diverting resources from another source to implement the project. The NED costs of a project include the design, construction, and maintenance of a project, as well as any associated costs (e.g., mitigation and property relocations). The NED benefits of USACE projects are typically damages and costs avoided. A project is considered feasible if the NED benefits are greater than the NED costs. The benefit-cost ratio for such a project would then be greater than unity, and the project would be deemed economically justified according to USACE policy.

Below is a listing and description of the NED categories that are typically considered for this type of study according to IWR Report 2011-R-09. Not all of these damage categories will be relevant for all studies.

Property Damage – The prevention of costs associated with repair, relocation, or abandonment (if damage is severe enough) of property would all be considered benefits of a project. Also, the cost of measures taken by property owners to prevent damage is relevant to the evaluation of potential project benefits. That is, if a project would save property owners from incurring costs associated with preventing damage to the property, the value of those expenses would be considered a benefit of a project.

Recreation Impacts – The value of recreation land or beach lost to erosion is typically calculated as the lost recreation value to users in accordance with their willingness-to-pay for the recreation experience. Willingness-to-pay can be measured various ways, but for a small study like this with a low-use recreation area, USACE typically uses the Unit Day Value (UDV) method[8]. This method relies on expert or informed opinion and judgment to approximate the average willingness-to-pay of users of recreation resources.

Land Loss – For USACE feasibility studies, the value of private land lost because of erosion is typically valued at the market value for the private land. The land at risk from erosion in the study area, however, is exclusively public. Public land loss can be captured as either the value of land OR the value of recreation lost, but not both.

Transportation Delay Costs – This impact is calculated as the sum of a) the time value of driver and passenger delay, and b) the additional vehicle operating costs as a result of a delay or detour. Only those delays and road closures that could actually be avoided by the proposed project may be counted; for example, the presence of the damaging storms with or without a project may be sufficient to precipitate road closure or delays.

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[8] http://planning.usace.army.mil/toolbox/library/EGMs/EGM13-03.pdf

Emergency Costs – Any emergency costs, such as the actions taken by police or other officials to reroute traffic around an eroded stretch of roadway, that would be avoided by the existence of a project would be considered a relevant NED benefit of a project.

Income Loss – This is the loss of wages or profits to business as a result of physical damages that cannot be deferred or transferred regionally. Prevention of income losses result in a contribution to NED only to the extent that the losses cannot be compensated for by postponement of an activity or transfer of the activity to other establishments.

Importantly according to the PGN, USACE policy is that recreation is generally incidental when it comes to project economic justification. From page E-133 of the PGN:

> The Corps participates only in those projects formulated exclusively for hurricane and storm damage reduction, and justified based solely on damage reduction benefits, or a combination of damage reduction benefits plus (at most) a like amount of incidental recreation benefits. In other words, recreation benefits useable to establish Corps participation may not be more than fifty percent of the total benefits required for justification, which in turn means they may not exceed an amount equal to fifty percent of costs. If the criterion for participation is met, then all recreation benefits are included in the BCR. Costs incurred for other than the damage reduction purpose, i.e. to satisfy recreation demand, are a 100% non-federal responsibility.

Given that the authority for this project is CAP §111, which is aimed at the mitigation of adverse impacts from a federal navigation project, it is possible that all of the recreation benefits could count towards project economic justification. But at this time it is not clear whether or not that is the case. Given that this is an open question, the analysis will address economic justification when constraining the recreation benefits to half the total benefits for justification, and when not constraining the benefits as such.

7.3 Future Without-Project Condition

The without-project (No-Action) condition, as its name suggests, is an assessment and forecast of the risks, assumptions, and conditions, assuming no USACE action. If erosion risk-reduction (or in-harbor sand removal) measures or any other actions are imminent or likely during the period of analysis without USACE's action, those measures and actions should be considered to be part of the without-project condition. Imminent measures and actions include those that are under construction, funded storm-protection measures, development under construction, development limitations as specified under the National Flood Insurance Program, Executive Order 11988, Coastal Zone Management Plans, and any state and local regulations in effect. Since future conditions sometimes include plans that have yet to be approved or may be speculative, USACE guidance states that all assumptions about including or excluding them in the future without-project condition should be carefully explained and justified.

One important future action that needs to be considered is a project that has been approved and funded to improve pedestrian safety and reduce the risk of erosion to Highway 1. According to a presentation to the San Mateo County Parks and Recreation Commission Meeting on April 9, 2015, the County of San Mateo, Caltrans, and the City of Half Moon Bay are partnering on the estimated $2 million project that is anticipated to be fully constructed in November of 2015[9]. The project will reduce the erosion risk to the highway by extending the riprap by around 200 feet, will improve access to the beach with a staircase, and will connect the Coastal Trail on either side of the project area.

The completion of this project is an important future without-project condition, since it effectively removes protection of Highway 1 as a benefit category for all alternatives. It also removes as a benefit category the protection of the most exposed portion of the California Coastal Trail that runs along Highway 1. This without-project assumption is included below in the list of major assumptions made for this analysis.

7.3.1 Major Assumptions

For coastal studies such as this, the consideration of future actions by others is especially important to the benefit-cost-analysis of the project. The critical future without-project assumptions of this analysis are:

- *Bluff Erosion Rate*: Any areas of the shoreline unprotected by a rock revetment in the study area will experience an average rate of bluff erosion of 1.6 ft./yr. According to the Coastal Engineering Appendix, the "natural" background rate of erosion is approximately 0.2 ft./yr., so, where applicable, the federal breakwater is assumed to cause 1.4 ft./yr. of erosion to the unprotected stretch of the study area where no revetment exists.

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[9] https://parks.smcgov.org/sites/parks.smcgov.org/files/events/20150409_REVISED_0403_0406_Agenda_Rescheduled_PRC-linked_0.pdf

- *Cabrillo Highway (CA-1)*: The previously-described project planned by Caltrans and San Mateo County to protect and improve the exposed stretch of the Highway 1 and the coastal trail will be completed before any federal project could be implemented.
- *Boat Ramp*: The boat ramp area will continue to accumulate sand, and periodic dredging will be necessary to provide safe and reliable access. The most recent three dredging episodes were in 1998, 2006, and 2013. The most recent dredge episode cost just over $530,000[10]. It is assumed that in the future dredging will continue to be required every seven years to maintain safe access to and use of the boat ramp.
- *Mirada Road Homes and Businesses*: The protective riprap that is in place along the bluff adjacent to Mirada Road will be maintained such that Mirada Road, adjacent homes, and businesses in the area will not be significantly adversely affected by future erosion.
- *20-year Period of Analysis:* According to the PGN, the period of analysis is defined as the duration of time over which the project will have significant beneficial or adverse impacts. The period of analysis must be the same for all alternatives considered. Although the engineering analysis estimates that some beneficial effect of the final array of alternatives could extend as long as 40 or 50 years from project completion, it is likely that the benefits after 20 or 30 years would be small because the visible beach for the beach fill alternatives will likely have disappeared within 10 years of project implementation.

7.3.2 Summary of Without-Project NED Impacts

Summing the estimates for the values of recreation impact, land loss, and boat launch dredging cost, the total annual NED impact under the without-project condition is estimated to be $199,000 (Table 5). It is important to note that not all of these impacts will be reduced or avoided by the project alternatives. As (Figure 14) shows, recreation loss accounts for more than half of the total present value of the estimated without-project damages.

Table 5: Summary of Future Without-Project NED Impacts

Year	Recreation Value Lost	Land Value Lost	Boat Launch Dredging Cost	Annual Total Nominal Value Lost	Annual Present Value Lost (2017)
2017	$14,162	$8,166		$22,328	$21,599
2018	$27,975	$8,166		$36,141	$33,820
2019	$41,438	$8,166		$49,604	$44,903
2020	$54,551	$8,166	$530,000	$592,717	$519,022

10 Source: San Mateo County Harbor District

2021	$67,315	$8,166		$75,481	$63,938
2022	$79,729	$8,166		$87,895	$72,023
2023	$91,793	$8,166		$99,959	$79,234
2024	$103,508	$8,166		$111,674	$85,630
2025	$114,873	$8,166		$123,039	$91,264
2026	$125,888	$8,166		$134,054	$96,189
2027	$136,553	$8,166	$530,000	$674,719	$468,330
2028	$146,869	$8,166		$155,035	$104,098
2029	$156,835	$8,166		$165,001	$107,173
2030	$166,452	$8,166		$174,618	$109,716
2031	$175,718	$8,166		$183,884	$111,767
2032	$184,635	$8,166		$192,801	$113,361
2033	$193,203	$8,166		$201,369	$114,532
2034	$201,420	$8,166	$530,000	$739,586	$406,920
2035	$209,288	$8,166		$217,454	$115,737
2036	$216,807	$8,166		$224,973	$115,830
Total Present Value of Damage					$2,853,487
Average Annual Damage (3.375%)					$198,510

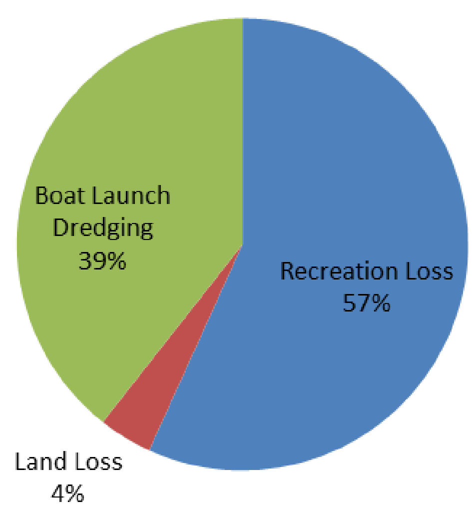

Figure 14: Proportion of Without-Project Damages by Category.

7.4 Economic Justification – Medium Beach Fill

This section describes the estimated NED benefits of the Medium Beach Fill alternative as described in the Coastal Engineering Appendix. A project is economically justified if its NED benefits equal or exceed the total NED cost of the project.

Implementing this beach fill project would be expected to widen the beach for at least 6 years under typical non-El Niño conditions. While there is a significant degree of uncertainty, it was assumed for this analysis that the visible beach created by this beach fill project would last for nine years. This assumption was made because the estimate of six years assumed a linear rate of annual sand loss, which, according to the Coastal Engineering Appendix, "likely overestimates the rate of loss after the initial period of adjustment to ambient hydrodynamic conditions." A 50% increase over the modeled lifespan of the visible beach was determined to be reasonable based on the professional judgment of the study team members. Table 6 shows the economic damages for each category for each year of the twenty-year period of analysis. Compared to the without-project NED impacts (Table 5), the with-project damages to recreation are simply delayed by nine years, which is reflected in the table by the downward shift in damages. Additional loss in land value from bluff erosion is assumed to be delayed for at least the twenty-year period of analysis since the sand is expected to persist in the nearshore for up to forty years.

Table 6: With-Project NED Impacts - Medium Beach Fill Alternative

Year	Recreation Value Lost) ($)	Land Value Lost ($)	Boat Launch Dredging Cost ($)	Annual Total Nominal Value Lost ($)	Annual Present Value Lost (2017) ($)
2017	0	0	0	0	0
2018	0	0	0	0	0
2019	0	0	0	0	0
2020	0	0	530,000	530,000	464,102
2021	0	0	0	0	0
2022	0	0	0	0	0
2023	0	0	0	0	0
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	14,162	0	0	14,162	10,162
2027	27,975	0	530,000	557,975	387,297
2028	41,438	0	0	41,438	27,824
2029	54,551	0	0	54,551	35,433
2030	67,315	0	0	67,315	42,296
2031	79,729	0	0	79,729	48,460
2032	91,793	0	0	91,793	53,971
2033	103,508	0	0	103,508	58,872
2034	114,873	0	530,000	644,873	354,809
2035	125,888	0	0	125,888	67,002
2036	136,553	0	0	136,553	70,306
Total Present Value of Damage					1,620,533
Average Annual With-Project Damage (3.375%)					112,737

Delay in Damage

The widened beach would be expected to not just temporarily prevent additional recreation value loss, but would also increase to some unknown degree the recreation value at the beach for as long as the additional visible beach persists. This additional value was not estimated for this study, however, in large part because the project authority is concerned with the mitigation of future adverse impacts and not with the creation or enhancement of recreation value.

Table 7 shows the results of the benefit-cost analysis for the Medium Beach Fill alternative. The annual damages reduced is the difference between the without- and with-project average annual damages, the net benefits are the difference between the average annual damages reduced and the average annual project costs, and the benefit-cost ratio is the ratio of average annual damages reduced and average annual costs. The results illustrate that the alternative is not economically justified. If analyzed assuming a higher opportunity cost of capital (greater discount rate), the benefit-cost ratio would be even lower. If the recreation benefits of the project were constrained to no more than 50% of the total benefits needed for justification, the benefit-cost ratio would be significantly lower than shown here.

Table 7: Benefit Cost Analysis Results - Medium Beach Fill Alternative

Without-Project Average Annual Damage	$198,510
With-Project Average Annual Damage	$112,737
Average Annual Damages Reduced	$85,773
Average Annual Costs	$348,000
Annual Net Economic Benefits	**($262,227)**
Benefit-Cost Ratio (3.375%)	**0.25**

7.5 Beyond the NED Impact—Regional Economic Development, Environmental Quality, Other Social Effects, and Public Safety

Per USACE Engineering Circular (EC) 1105-2-409[11], any alternative plan that has net beneficial effects across the four USACE Planning & Guidance accounts may be the recommended plan. The four accounts are: NED, Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). Furthermore, "highest budgetary priority will be given to collaborative planning activities that embrace the full range of the national federal interest." The project is anticipated to have positive, but small, impacts to the other three accounts." The following two sections will briefly describe those accounts.

7.5.1 Regional Economic Development

According to the Planning Guidance Notebook, ER 1105-2-100, "the regional economic development account registers changes in the distribution of regional economic activity that result from each alternative plan". In general, the RED account shows the effects of different plan alternatives on the distribution of regional economic activity in the area where implementation of the plan will have significant impacts on income and employment. The EC dictates that

11 This EC expired 9/30/2007.

measurement of RED effects is generally to be quantitative within available and selected methods.

From a regional perspective, project construction will have a minor beneficial impact on the economy. Implementation of the project would result in additional construction expenditure and demand for both construction labor and construction support services, providing short-term regional economic benefits. Expenditure on labor and services would have a trickle-down effect throughout the region as increased employment opportunities and higher overall earnings generate spending and inter-industry economic activity. The number of employment opportunities and their length is highly limited, however, because the dredge and placement sites are in close proximity. Because the increment of construction attributable to the project is small, the beneficial impact on the economy is expected to be positive but small. Because the impact is expected to be small, for practical reasons the regional economic impact has not been quantified (Table 8).

Table 8: Summary of RED and OSE Outputs

	Alternative	No-Action	Dune Only
Regional Economic Development	Benefit to Regional Industry	N/A	N/A
	Regional Construction Industry	N/A	Temporary benefit
Other Social Effects	Flood Risk	None	None
	Aesthetics	N/A	Positive: No visible riprap
	Recreational Benefits	N/A	Positive: Users will have more access to the area in front of the dune, especially as waves redistribute sand, creating beach
Public Safety	Beach Access	Negative	Positive
	Protection of Great Highway	Negative	Positive
	Wastewater exposure and infrastructure failure	Negative	Positive
Other Impacts	Constructability Risks	N/A	Low: Bulldozers will have to work at the edge of the surf zone, but the operators are experienced in the area
	Hardening structures required	N/A	N/A

Continued erosion over the period of analysis would be expected to have some adverse impact to the local and regional economy, but the impact would likely be small. That is not to say that there will be no impact, but rather just that the impact will not be significant in the context of overall local and regional sales, jobs, and tax revenues. This is because the changes in the study area over time would not significantly adversely affect the main draw for the hotels and restaurants in and around Pillar Point Harbor, which are the view, the harbor ambiance, and the many regional recreational opportunities.

7.5.2 Other Social Effects and Public Safety

The OSE is defined by EC 1105-2-409, "The other social effects account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts". Because the project is expected to reduce the short-term risk of coastal storm damage, the project is expected to have a positive social and safety impact (Table 8).

7.6 Sensitivity Analysis

Uncertainties abound in this analysis. The future rate of erosion, the human response to changed conditions in the area, and the effectiveness and duration of the beach fill projects are all unknowable and involve a great amount of uncertainty. The analysis relies on complex and detailed coastal modeling but also to a large extent on professional judgment, local knowledge, and anecdotal evidence. Using what are considered the most-likely, middle-of-the-road future scenarios and assumptions, the preferred alternative is not economically justified.

The total without-project average annual damages are less than the average annual cost of the proposed action, which means that the action would not be economically justified by changing assumptions or data related to the with-project effectiveness. For the benefits to exceed the costs, the without-project damages would have to be approximately twice as large as estimated, and the beach fill projects would essentially have to eliminate all damages over the period of analysis.

The proposed action would involve a one-time dredging of approximately 140,000 to 150,000 yd^3 of sand accumulated along the East Breakwater and placement of that sand to form a 125-foot wide elevated berm along the approximately 3,100-foot long section of shoreline that makes up Surfer's and Vallejo Beaches. The proposed action would not have significant adverse indirect or cumulative impacts on the physical, biological, and human environment. Temporary and minor direct adverse effects associated with the proposed action are expected to be short in duration, ending with the completion of construction activities, and would be less than significant given the assumed avoidance measures and BMPs described in this assessment. Long-term impacts of the proposed action would be beneficial in terms of minimizing erosion, removing navigational hazards, and improving recreation and habitat at the project site.

Because the NED analysis shows the benefit-to-cost ratio for the proposed action is 0.25, and a ratio greater than 1.00 is needed to justify federal action by USACE, a federal project is not recommended. If another entity decides to go forward with a similarly designed project, the results of the economics, engineering, and environmental analyses will be available through the NFS (the SMCHD).

There are still opportunities to address erosion at Surfers Beach through the continued efforts and partnership of the Harbor Commission, the Beach Replenishment Committee, Caltrans, and the other agencies with the support of the MBNMS. In their letter to the San Mateo County Harbor District, Board of Commissioners, dated July 28, 2015, the National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries stated that they are prepared to work with the Harbor Commission, the Beach Replenishment Committee, Caltrans and the other agencies during the development of any potential alternatives to ensure that a comprehensive and coordinated approach is taken to addressing erosion at Surfer's Beach. The National Marine Sanctuary believe there are some feasible options, both short-term and long-term to address the myriad issues at Surfer's Beach and in the harbor. The first, and their preferred, short-term option involves sourcing sand from the shoal that has formed nearby, inside the outer breakwater of Pillar Point Harbor, and placing it above MHW along the Surfer's Beach so that sand can naturally work into the littoral system and help attenuate erosion; we believe there is an available deposition zone between 80 – 140 feet wide in that area between the bluff and the mean high water line. This alternative would not require a sanctuary permit because sand would be placed outside the boundaries of the sanctuary. If the Harbor

Commission were to pursue this option, the MBNMS would work with the commission and other agencies to provide historic shoreline data for the Surfer's Beach area to determine a baseline for the sanctuary's boundary.

A second short-term option that also could be considered would be to source sand other than from harbor dredge sources, perhaps from upland areas beyond MBNMS, and truck it to and place it below mean high water along Surfer's Beach. This option could possibly be permitted within MBNMS regulations provided that the pilot project design meets strict resource protection standards and MBNMS permit issuance criteria. The NMFS would like to continue to be engaged in this planning process by working collaboratively with the Harbor Commission's Beach Replenishment Committee to develop both short-term and long-term options for addressing erosion along this stretch of coast that would serve as sustainable and effective alternatives to coastal armoring.

Long-term options that might be considered include additional beach nourishment above MHW, including source sand from within the harbor, provided that pilot studies and placement episodes prove effective and protective of sanctuary resources; evaluating the feasibility of a planned managed retreat of Highway 1 to eliminate the need for further coastal armoring (like rock slope protection) and to allow for the beach to be restored; and modifying the outer breakwater, which has contributed significantly to the erosion occurring in this area by interfering with the natural sediment transport along this stretch of coast.

In addition, the USACE Regional Sediment Management (RSM) Program[12] provides opportunities for USACE to collaborate with stakeholders and other agencies to leverage resources, share technology and data, and develop and implement innovative solutions to improve regional utilization and management of sediments. As a part of this initiative, the RSM Program's annual Request for Proposals provides an opportunity for funding the permitting and monitoring of material placement at Surfer's Beach. Currently, the SPN has been in contact with the RSM Program Manager to initiate discussions on how RSM Program funds can be applied to assist in addressing shoreline erosion through future sediment placement at Surfer's Beach.

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[12] http://rsm.usace.army.mil/

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