Exhibit F

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Exhibit F.1

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Section II

Coastal Development

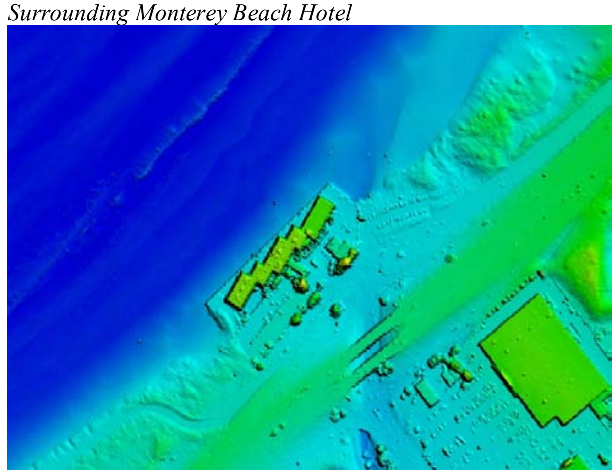
- **Coastal Armoring Action Plans**
- **Desalination Action Plans**
- **Harbors and Dredge Disposal Action Plans**
- **Submerged Cables Action Plans**

Coastal Armoring Action Plan

Goal

Reduce expansion of hard coastal armoring in the coastal areas near the MBNMS through proactive regional planning, project tracking, and comprehensive permit analysis and compliance.

Figure CA-1: NOAA LIDAR Image of Armored Coastline Surrounding Monterey Beach Hotel



Introduction

Shoreline protective structures have been used extensively along California's coastline to protect infrastructure and other development from wave action, or to retain soil to avoid erosion. Private landowners and local, state, or federal governments have typically installed structures in an attempt to protect development threatened by coastal erosion. Structures have also been installed to protect public infrastructure such as Highway 1, which in some stretches is vulnerable to erosion related to bluff retreat. This practice is commonly known as coastal armoring, and seawalls, bulkheads and revetments are some of the structures that are used. Seawalls are barriers, usually vertical walls, between the land and water that protect from wave erosion. A bulkhead is used as a retainer, providing protection and stabilizing the land that it supports. Revetments are protective structures placed along slopes and are constructed of a sturdy material such as stone.

Increases in development and continued, natural erosion of coastal bluffs will cause additional pressure to install structures to protect private and public property from erosion. Development is continuing to occur in vulnerable areas along California's coast, followed by a desire to protect both private and public property. The situation presents a serious predicament to both resource managers and property owners. However, it is clear that current policies need strengthening, and there is a need to develop collaborative approaches to address the issues of erosion and the demand for coastal armoring, including improved guidance to enable better decision making.

Sanctuary regulations prohibit alteration of the seabed, and all armoring structures placed below the mean high tide line require approval from the MBNMS. The Sanctuary regulates coastal armoring by authorizing California Coastal Commission permits, and placing specific conditions on those permits. Many seawalls have been constructed with no notification to or authorization from the MBNMS. Since 1992, MBNMS review of seawalls primarily focused on minimizing impacts from the construction process rather than long-term impacts from the armoring itself. Since its designation, MBNMS has reviewed and authorized California Coastal Commission permits for seawalls, riprap or other coastal armoring projects at fifteen sites. Only a portion of the total coastal armoring projects underway in the region came to the Sanctuary for review, clearly indicating a need for improved inter-agency coordination.

As with any activity that alters natural processes, there can be significant long-term impacts related to coastal armoring. Environmental impacts of coastal armoring vary significantly depending on the type of structure constructed, the magnitude of the project, and the specific geological, biological, and oceanographic conditions in the vicinity of the structure. Coastal armoring can potentially damage or alter local coastal habitats, deprive beaches of sand, lead to accelerated erosion of adjacent beaches, hinder access, and present problems with public safety. Coastal armoring projects may impede and eventually cut off access to significant stretches of public beaches.

Currents, waves, and wind normally transport sediment throughout the littoral system. Armoring of the coast can interfere with littoral transport, which in a natural state may reach a dynamic equilibrium. When the availability of sediment is reduced due to the existence of a structure, erosion can increase in other nearby locations. Vertical structures in particular can deflect wave energy causing increased erosion and altering natural habitat in front of the structure. Reflected wave energy may make it difficult for organisms to inhabit the area because of high turbidity.

Coastal armoring can negatively impact certain biological resources by causing changes in abundance and distribution of species. Coastal armoring structures can influence the structure of benthic communities, due to potential differences in settlement patterns for natural substrates and armoring structures. Armoring structures can encroach into the intertidal zone or disturb important buffer areas such as marsh habitat between the marine and terrestrial environments, which naturally mitigate erosion, and play an important role in flushing certain contaminants.[2] Certain structures can also provide habitat for predatory species not normally associated with the beach and intertidal zone such as rats and squirrels, which can feed on intertidal organisms, compete for food with native species, and transmit disease. Additionally, coastal armoring can act as a barrier to wildlife, by blocking access of certain species to the beach.

The construction phase of coastal armoring projects generally causes short-term impacts, lasting only a few days to a few weeks. Problems include increased turbidity caused by suspended solids in the immediate vicinity of the construction site, and the risk of chemicals or other materials entering the ocean from construction activities. Structures constructed in the intertidal zone generally have more impact than those constructed above the high tide line. Many short-term construction impacts can be minimized through appropriate mitigation measures, including scheduling of the construction phase to reduce impacts by considering animal migration patterns and spawning patterns or specific actions such as the use of silt curtains. However, the long-term impacts of coastal armoring projects are more difficult to address or prevent, and they are a key focus of this action plan.

Strategy CA-1: Conduct Issue Characterization and Needs Assessment

Implementation of this strategy will identify existing information and data gaps, and compile and produce the necessary scientific data and evaluation tools. This will also involve an in-depth analysis of a subregion of the MBNMS and then development of a long-term monitoring program based on its success.

Activity 1.1: Produce MBNMS-wide Maps and Database for use as Planning and Permit Review Tools

The MBNMS will coordinate with partners to map existing coastal armoring sites and potential future site requests based on evaluation of coastal erosion rates and development patterns. The MBNMS will also coordinate with partners to develop a regional integrated database and Geographic Information System (GIS) layers showing land use types, parcels, coastal armoring locations, beach and bluff erosion and replenishment rates, bottom types, biological habitats, and geology/geomorphology. This database system should become integrated with Sanctuary Integrated Monitoring Network (SIMoN) to facilitate use by other agencies and the public.

Activity 1.2: Compile and Analyze Ecological and Socioeconomic Data

This activity is a long-term characterization that will begin as a pilot project with an in-depth analysis on a critical subregion. The MBNMS will first coordinate with partners to identify methods and to assess individual and cumulative impacts of coastal armoring on sand supply dynamics, marine biological habitats and ecosystems, and public access. Compilation of this data should include studies to estimate coastal bluff erosion rates, and shoreline change rates and a regional evaluation of sand transport dynamics and beach nourishment.

Activity 1.3: Incorporate Data and link with State Programs

Incorporate data into maps and database from Activity 1.1, and link to State of California's COASTAL SEDIMENT MANAGEMENT MASTER PLAN.

Activity 1.4: Develop and Implement a Long-term Monitoring Program

Quantify and compare the impacts of different types of coastal armoring structures in various habitat types and conditions. Considerations for monitoring program include intertidal biological community structure, changes in beaches, wave refraction patterns, and impacts on sand budget.

Strategy CA-2: Develop and Implement Regional Approach to Coastal Armoring

MBNMS will collaborate with partners to develop and implement a more proactive and comprehensive regional approach that minimizes the negative impacts of coastal armoring. This approach will consider impacts throughout the life of the structure from construction and maintenance to the long-term cumulative impacts.

Activity 2.1: Apply Hierarchy of Preferred Responses to Erosion

The MBNMS will use the following hierarchy of responses as preferred approaches to addressing coastal erosion that may threaten structures.

A. *Use of preventative measures*
   Identify and evaluate preventative measures aimed at reducing the need for coastal armoring. Considerations may include increased setback requirements, incorporation of a "no hard armoring" policy (possibly in covenants, codes, and restrictions) for new subdivisions or situations when coastal agricultural land is converted to development, re-alignment of coastal roads and highways, and new setback requirements to be established for demolition/rebuild projects in urbanized areas.

B. *Alternatives to coastal armoring*
Identify and evaluate alternatives to coastal armoring, including but not limited to: (a) alternatives conforming to MBNMS regulations such as relocation of vulnerable structures, re-alignment of coastal infrastructure such as roads, bridges, and highways, and control of surficial erosion; and (b) alternatives not conforming to MBNMS regulations, including some sand supply strategies and artificial reef structures.

C. *Preferred types of coastal armoring*
In cases where armoring is deemed necessary, identify and evaluate the least environmentally damaging types of coastal armoring, including more natural alternatives for specific conditions and geographic locations, taking into account engineering, environmental, aesthetic and public access concerns.

Activity 2.2: Develop and Implement Guidelines for Identifying Sub-regions

Guidelines will be developed with partners to identify pristine or particularly sensitive areas where coastal armoring should be strongly discouraged or not allowed; urban zones that are already heavily armored and where efforts should focus on restoration and improved armoring techniques; and areas in-between where thorough case-by-case review and additional research is needed.

Activity 2.3: Identify Planning Sub-regions

MBNMS staff will work with partners to identify boundaries for sub-regions and consider measures developed in Activity 2.1 to determine planning approaches for each sub-region. Sub-region and size will be based on complexity and continuity of similar habitats or land uses. This may include continual habitats of rocky shores, sandy beaches, littoral cells, estuarine environments, and land use such as existing armoring, urban areas, rural coastlines, or beaches with heavy visitation. These areas will be identified based on ecological and land use criteria for identifying planning sub-regions for coastal armoring policies and strategies. Identifying sub-regions should be based on: (a) biological sensitivity of habitats; (b) physical considerations, including geological factors such as sediment sources and sinks, beach nourishment needs, shoreline orientation and erosion rates; and (c) development pressures, including the extent of existing armoring, potential for new armoring requests, types of structures to be protected, and level of development and infrastructure.

Activity 2.4: Develop Specific Planning Guidelines for each Sub-region

MBNMS staff will work with partners to develop specific planning guidelines for each sub-region identified in Activity 2.3, based on application of the hierarchical approach as stated in Activity 2.1. All policy development and application of guidelines to sub-regions should involve significant outreach to affected parties and agencies. Sub-regions will be addressed sequentially beginning with an initial pilot region in Southern Monterey Bay.

Activity 2.5: Develop Maintenance and Restoration Program

MBNMS staff will work with partners to develop a program for maintenance and restoration of existing armoring, including "clean-up" of poorly maintained sites, for both authorized and illegal structures. If or when maintenance is requested, MBNMS and partners will re-evaluate the need for protection. All maintenance and restoration programs should incorporate improvements in beach access and public safety. In heavily armored areas where maintenance is necessary and appropriate, MBNMS and partners will consider the potential for installation of a comprehensive, uniform structure to replace multiple individual structures.

Activity 2.6: Reduce Need for Emergency Permits

The MBNMS will coordinate with partners to reduce the use of and need for emergency coastal development permits through better predictive erosion analyses, potential alteration of current guidelines regarding initiation of work, and more proactive regional planning. Staff will consider areas where it is appropriate to either initiate the work or develop alternative solutions, before the site becomes an emergency.

Activity 2.7: Broaden the Multi-Agency Enforcement Program

MBNMS will work with partners to develop cooperative enforcement mechanisms for inspection of permitted coastal armoring structures, tracking/notification and corrective action regarding illegal structures, assessment of fines, and removal of emergency structures that are not permitted to remain in place permanently.

Activity 2.8: Pursue Pilot Program for Alternatives to Coastal Armoring

Based on the scientific and needs assessment, MBNMS will pursue a pilot program to investigate environmentally sound alternatives to coastal armoring, and develop and implement monitoring protocols for the program. Alternatives will include but not be limited to: preventative measures, planned retreats, beach nourishment, and structural responses such as groins or breakwaters.

MBNMS will convene interagency working groups to identify and help design sub-region specific design alternatives for the coastal erosion responses identified in Activity 2.1. Considerations will include:

A. Identifying the suite of preventative measures such as restricting activities that contribute to erosion, predevelopment conditioning of projects and the necessary legal measures or relocation of structures such as road realignment or development demolition, or enhanced vegetation of exposed, erosion prone areas.
B. Identifying hard structures that may preempt erosion or help retain sand on beaches. Types of structures may include groins (narrow wooden or concrete constructions that extend from a shore into the sea to protect a beach from erosion), offshore seawalls, breakwater, or submerged structures such as artificial reefs that dissipate wave energy prior to reaching the shoreline. All hard structures would alter the seabed and therefore trigger review by MBNMS as a prohibited activity.
C. Identifying appropriate sources of beach quality material and one or more locations for one or more pilot demonstration projects that might receive an MBNMS scientific research permit (and other necessary agency permits) to test and develop appropriate sand supply and beach nourishment program options. MBNMS will develop a coordinating mechanism with the California Coastal Sediment Management Workgroup to promote the exchange of information and ideas. If appropriate sources of sand and potentially beneficial nourishment sites can be identified, the pilot study or studies would develop specific research objectives and study methodologies. Criteria for "success" will also be developed. The criteria could include minimal environmental impacts, recreational access, shoreline protection and habitat benefits, the potential for using maintained

nourishment to avoid or mitigate for shoreline armoring, and other identifiable overall benefits to MBNMS resources.

At the conclusion of this/these demonstration pilot project(s), the agency working group will evaluate the desirability of, and necessary steps for, continuing such a program involving beach nourishment within MBNMS boundaries. If the sand supply project is to continue, this evaluation will also examine whether revision of MBNMS regulations may be warranted, if a beneficial program might continue via MBNMS permit or authorization in concert with other regulatory agencies.

Strategy CA-3: Improve Permit Program

MBNMS will improve the current case-by-case permit system and strengthen coordination with other agencies regarding coastal armoring permit processing.

Activity 3.1: Integrate State and Federal Planning Programs

Where possible, MBNMS will link and integrate aspects of the MBNMS coastal armoring plan with California state erosion policy and Coastal Sediment Management Master Plan.

Activity 3.2: Develop Consistent Permitting Conditions

Following the initiation of regional analysis from Strategy 2, identify permit conditions and authorization criteria of the agencies involved in the regulation of coastal armoring. Staff will subsequently compare typical multi-agency seawall permit conditions, identify and discuss selected discrepancies, and where possible seek to rectify discrepancies.

Activity 3.3: Incorporate MBNMS Standard Conditions into Other Agency Permits

The MBNMS will coordinate with the California Coastal Commission to incorporate current MBNMS standard conditions regarding construction processes into Coastal Commission permits

Activity 3.4: Clarify Level of MBNMS Involvement in Projects and Develop Review Thresholds

MBNMS staff will develop and identify a threshold for full MBNMS review of selected projects based on overall footprint, location, and potential impacts, and ensure early communication on these projects.

Activity 3.5: Share Information with Other Agencies

MBNMS staff will continue to improve early sharing of information on projects and permits among all relevant agencies.

Activity 3.6: Conduct Permit Enforcement Inspections and Actions

The MBNMS will conduct enforcement inspections of permitted coastal armoring activities and follow up to ensure compliance with conditions of permits and authorizations. The MBNMS will conduct general surveillance patrols to detect coastal armoring activities being conducted without required permits.

Strategy CA-4: Implement Programs and Increase Training

MBNMS will provide outreach and training to local, state and federal agencies and the general public about the sanctuary's sub-regional approach to addressing the issue of coastal erosion.

Activity 4.1: Conduct Needs Assessment

MBNMS staff will conduct a needs assessment to determine best strategies for reaching target groups including: decision makers, agencies, coastal landowners, and coastal developers.

Activity 4.2: Conduct Outreach to Agencies and Property Owners

MBNMS will coordinate with partners to increase outreach to agencies not involved in the planning process, developers, and private property owners about regional approaches to coastal erosion, existing guidelines, and the impacts of coastal armoring.

Activity 4.3: Review and Comment on Local Land Use Decisions

MBNMS staff will track and evaluate local and regional land use decisions where coastal development may impact MBNMS resources. Where appropriate, produce verbal or written comments on specific projects.

Activity 4.4: Review and Comment on Local Coastal Program Updates

MBNMS will coordinate with the California Coastal Commission and local agencies during Local Coastal Program updates to improve existing policies and incorporate coastal armoring guidelines where possible.

Action Plan Partners: California Coastal Commission, United States Geological Survey, California Department of Transportation, California Department of Boating and Waterways, Local Municipalities, Research Institutions, California Department of Fish and Game, Local Jurisdictions, Local Experts, Elkhorn Slough NERR, Property Owners

Table CA.1: Measuring Performance of the Coastal Armoring Action Plan

Desired Outcome(s) For This Action Plan:	
Reduce expansion of hard coastal armoring in the coastal areas near MBNMS through proactive regional planning, project tracking, and comprehensive permit analysis and compliance.	
Performance Measure	**Explanation**
By 2012, complete three collaborative coastal erosion response plans for the planning sub-regions of the MBNMS.	MBNMS will track performance annually through the development of three detailed plans for three sub-regions that will include: an analysis of coastal erosion and management response including an analysis of local and regional alternatives to manage coastal erosion.

Table CA.2: Estimated Timelines for the Coastal Armoring Action Plan

Coastal Armoring Action Plan	YR 1	YR 2	YR 3	YR 4	YR 5
Strategy CA-1: Conduct Issue Characterization and Needs Assessment					
Strategy CA-2: Develop and Implement Regional Approach to Coastal Armoring					
Strategy CA-3: Improve Permit Program					
Strategy CA-4: Implement Programs and Increase Training					

Legend

Year Beginning/Ending :	Major Level of Implementation:
Ongoing Strategy :	Minor Level of Implementation:

Table CA.3: Estimated Costs for the Coastal Armoring Action Plan

Strategy	Estimated Annual Cost (in thousands)*				
	YR 1	YR 2	YR 3	YR 4	YR 5
Strategy CA-1: Conduct Issue Characterization and Needs Assessment	$198	$98	$106	$64	$80.4
Strategy CA-2: Develop and Implement Regional Approach to Coastal Armoring	$17	$53	$61	$33	$24
Strategy CA-3: Improve Permit Program	$8	$8	$8	$8	$4
Strategy CA-4: Implement Programs and Increase Training	$4	$14.5	$19.5	$15.5	$11.5
Total Estimated Annual Cost	*$227*	*$173.5*	*$194.5*	*$120.5*	*$119.9*

* Cost estimates are for both "programmatic" and "base" (salaries and overhead) expenses.

Desalination Action Plan

Goal

Minimize the impacts to sanctuary resources and qualities from desalination activities.

Introduction

Desalination is the process by which salts and other chemicals are removed from salt or brackish water and other impaired water resources. It is also known as desalinization or desalting or commonly referred to as "desal." As traditional sources of fresh water continue to be depleted and degraded, society is increasingly looking toward desalination as an option for obtaining water for both private and municipal freshwater supply. Various water project proponents are increasingly attracted to desalination due to increasing efficiency in desalting technologies' ability to produce the water as well as escalating costs of obtaining fresh water from conventional sources.

Three desalination facilities currently operate within the boundaries of the Monterey Bay National Marine Sanctuary (MBNMS); however, there has recently been an increase in interest for both private and public desalination plants. Approximately ten facilities have recently been proposed. Rather than utilizing a coordinated regional planning approach, each plant has been conceived and designed as a separate project. Due to population growth in the area, continuing shortages and degradation of conventional water supplies, and advances in desalination technology, the trend will likely continue.

Desalination plants can impact the marine environment through the introduction of brine effluent and other substances to MBNMS waters. Construction of desalination facilities and associated pipelines often causes alteration of the seabed. Intake of water directly from the ocean typically results in biological impacts as a result of impingement and entrainment. Impingement is when organisms collide with screens at the intake, and entrainment is when species are taken into the plant with the feed water and are killed during plant processes. In addition, desalination facilities bring a potential for community growth. Along most of California's central coast, fresh water supply is the limiting factor for community growth. With the addition of an unlimited source of freshwater, growth can be allowed to occur. While population growth is not addressed directly by MBNMS regulations, it is of major concern. Significantly increased development of the coastline adjacent to the MBNMS could lead to degradation of water quality and many other challenges to the protection of MBNMS resources.

This action plan is developed as a regional approach to address desalination, aimed at reducing impacts to marine resources in the MBNMS through consideration of regional planning, facility siting issues, on-site mitigation measures, modeling and monitoring, and outreach and information exchange.

Desalination in the Sanctuary

Three of the Sanctuary's regulations relate directly to desalination. The first involves a prohibition on discharging or depositing any material or other matter within Sanctuary boundaries. Since the brine effluent, and in some cases other material, are usually disposed of in ocean waters, this activity requires Sanctuary authorization of Regional Water Quality Control Board (RWQCB) permits. The second Sanctuary regulation pertains to discharging material or other matter outside of the boundaries, which subsequently enter Sanctuary waters and injure MBNMS resources or qualities. As with the previous regulation, Sanctuary approval via authorization of the RWQCB permit is required. The third relevant regulation involves a prohibition on activities that alter the seabed. Thus installation of certain desalination facility structures such as an intake/outfall pipeline on or beneath the ocean floor would also require Sanctuary authorization.

Three small desalination plants currently operate in the Sanctuary:

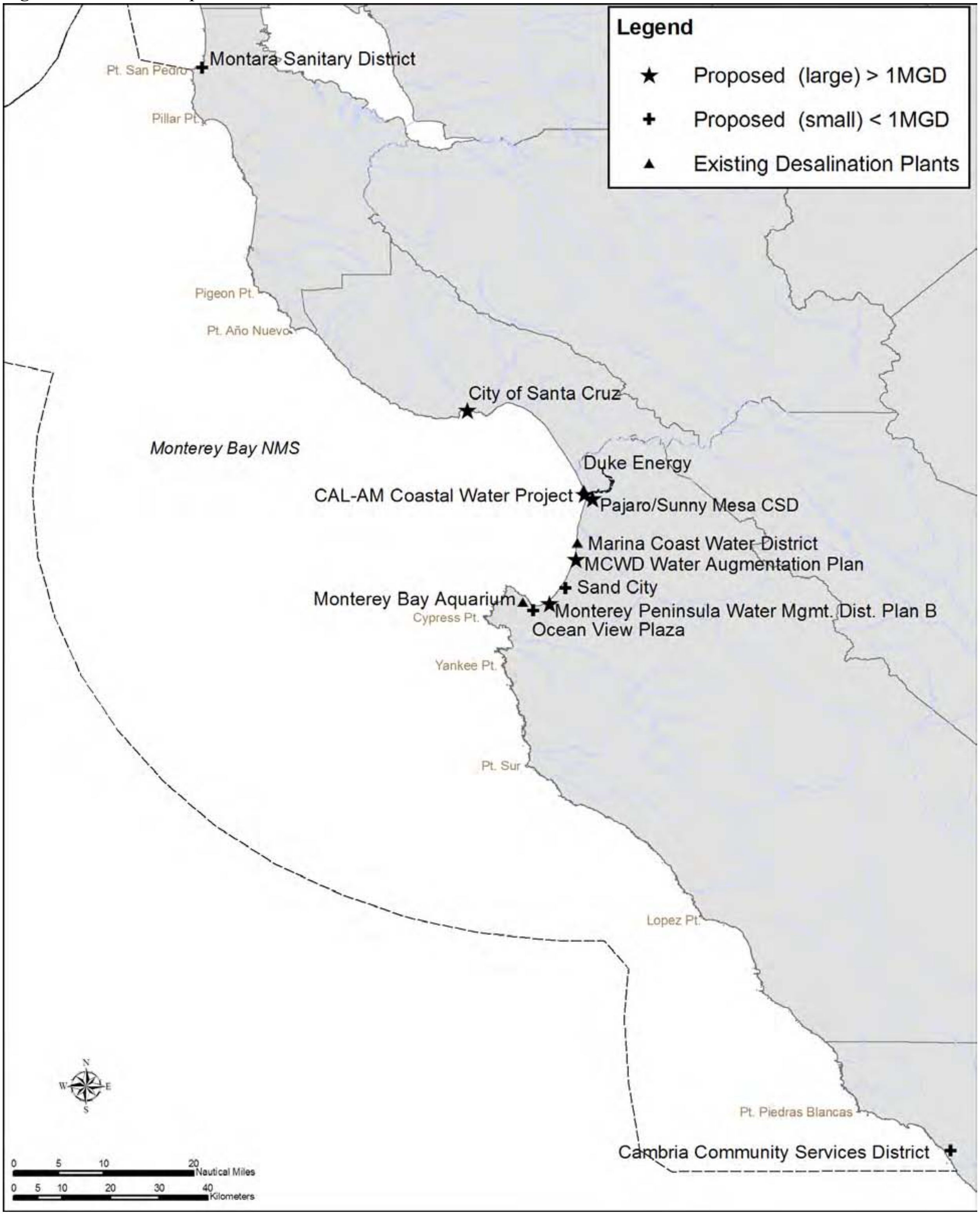
Duke Power Plant in Moss Landing contains a seawater distillation plant that produces a little less than 0.5 million gallons per day (MGD) for use in its boiler tubes for the power production process. This facility uses power plant cooling water as the source for the desalination feed water and brine effluent discharge. Due to the large volume of cooling water being discharged by the plant, the brine effluent is diluted and impacts from the salinity are eliminated.

Marina Coast Water District in the City of Marina operates a small plant with the capacity of 0.45 MGD, which currently supplies about 13 percent of the city's annual municipal water consumption. This plant uses a beach well for intake water and an injection well for discharging brine effluent. This facility, originally built in 1996, will be renovated in the near future with new technologies that will greatly increase its efficiency.

The Monterey Bay Aquarium operates a very small facility that provides about 0.040 MGD for maintenance purposes such as flushing the toilets. The saline brine discharge is blended with, and effectively diluted by, the exhibit water outfall.

Although there are currently only three facilities in operation, there has recently been an increase in proposals for both private and public desalination plants. Approximately ten additional facilities in the Sanctuary region are in some stage of initial consideration or planning (See Figure DESAL-1). These range from small, less than 0.050 MGD private facilities such as the proposed reverse osmosis plant for the Ocean View Plaza to be built on Cannery Row in Monterey, to larger multi-city regional projects like the ones Cal-Am and Pajaro Sunny Mesa Community Services District are currently investigating. There are also several proposals for smaller projects to serve a single city, such as the proposed plants in Cambria or Sand City. Due to population growth in the area, continuing shortages and degradation of conventional water supplies, and advances in desalination technology, the trend will likely continue.

Figure DESAL-1. Proposed or Potential Desalination Facilities



Strategy DESAL-1: Develop and Implement Regional Desalination Program

MBNMS will collaborate with partners to encourage the development and implementation of a regional planning program to address desalination facility development and operation in the MBNMS. A comprehensive regional approach to desalination issues would likely help minimize the impacts to resources by providing increased coordination and planning among desalination proponents and relevant agencies that are now addressing a multitude of independent desalination proposals.

Activity 1.1: Encourage the Development of and Provide Input to a Regional Planning Program

The MBNMS staff will collaborate with partners in the development and implementation of a regional planning approach to desalination that considers siting, volume of water requested, service areas, and potential collaborations. The following system standards and an analysis will be incorporated into the program:

A. Develop and implement a system for improved coordination among agencies involved in permitting desalination, and among interested parties, in implementing the following strategies and activities in this action plan.
B. Ensure opportunity for input from local jurisdictions and the interested public.
C. Investigate potential for and encourage use of full capacity of existing desalination facilities before approval of construction of new plants.
D. Develop and implement a system to improve tracking of new desalination proposals in order for the MBNMS and other agencies to enter into discussion with desalination plant proponents and interested parties early on in the process.
E. Evaluate regional opportunities for joint facilities serving multiple jurisdictions, collocation of facilities at existing discharge sites, etc. Evaluate advantages and disadvantages of joint facilities versus several smaller well-sited plants.
F. In collaboration with the California Coastal Commission, consider the ramifications of public versus private ownership of desalination facilities.
G. Facilitate assessment and analysis of the potential growth inducing impacts of desalination plants in the region with other interested agencies and parties. Affected local governments, Association of Monterey Bay Area Governments (AMBAG), the Coastal Commission and other appropriate land use entities will be looked to for providing information and analysis on potential growth inducing impacts.

Strategy DESAL-2: Develop Facility Siting Guidelines

Environmental impacts in large part depend on specific physical and biological conditions in the vicinity of the facility, including the intake and outfall. Through proper siting of facilities and intake/outfall structures, impacts can be minimized. The goal of this strategy is to develop and implement a set of desalination facility siting guidelines and recommendations to minimize impacts to MBNMS resources and qualities.

Activity 2.1: Identify Preferred Conditions and Habitats

Building on the work done by California Department of Fish and Game and others, identify preferred conditions and habitats types that are the most resilient to the impacts of brine effluent, as well as sensitive species and habitats where brine effluent disposal should be avoided.

Activity 2.2: Develop Intake/Outfall Siting Guidelines

The MBNMS will coordinate with the appropriate regulatory agencies to develop and implement recommendations and guidelines for siting of intake and outfall structures, which require appropriate outfall siting and design that ensures adequate mixing and dilution of brine effluent. Considerations for siting include avoiding areas with limited water circulation and ensuring discharge to an appropriate depth and distance offshore. Guidelines should encourage use of appropriately sited existing pipelines of acceptable structural integrity to minimize seabed alteration. Other considerations include mixing of brine effluent with power plant cooling water or sewage treatment plant discharges where appropriate and ensuring that temporal variations in operation and maintenance of facilities are addressed to ensure sufficient dilution of brine effluent. In cases where new pipeline construction is required, it is vital to ensure proper routing and construction techniques to minimize environmental impacts e.g.,impingement and entrainment, recreational impacts, potential for the effluent to be entrained in the intake, and potential for concentration of contaminants in the feed water.

Activity 2.3: Ensure Comprehensive Consideration of Potential Impacts

The MBNMS will coordinate with the appropriate regulatory agencies, to develop and implement recommendations and guidelines to ensure that planned facilities consider:

A. Aesthetic, recreational, public access, and safety aspects
B. The effects of surface waves, circulation, density, and mixing, on the dispersal of brine effluent
C. Surface wave and sea level effects and geological considerations, including earthquake hazards, liquefaction, sand transport patterns, and beach erosion rates for proposed structures to be located on or near beach
D. Alternatives analysis for water supply needs and supply options under NEPA and CEQA
E. Emergency contingencies and incorporation of system-wide fail-safe technologies to address the potential for emergency scenarios (mechanical failures, terrorist attacks, etc.)
F. Potential cumulative impacts from multiple facilities

Strategy DESAL-3: Identify Environmental Standards for Desalination Facilities

Specific engineering and design aspects of desalination plants are a major determinant of the severity of the impacts to the marine environment. There is an increasing range of technologies available, including many promising new advances in intake design, pretreatment, reverse osmosis, and brine disposal technology. This strategy defines and seeks to implement environmental standards for desalination facilities operating in the MBNMS. The MBNMS will collaborate with partners to define specific standards that proposed facilities would be required to meet through proper design and engineering. Compliance with standards shall be measured using requirements included in Strategy DESAL-4: Modeling and Monitoring Requirements.

Activity 3.1: Define Limits for Constituents of Brine Effluent

MBNMS staff will collaborate with the appropriate regulatory agencies to define and implement limits for salinity levels, toxicity, anti-corrosion additives, and other constituents of brine effluent. Standards shall take into consideration potential cumulative impacts from multiple facility operations.

Activity 3.2: Define Entrainment and Impingement Standards

MBNMS staff will coordinate with partners to define and implement environmental standards for entrainment and impingement including identification of preferred designs, screening, intake well siting, and maximum flow velocities. Standards shall also consider potential cumulative impacts from multiple facility operations.

Strategy DESAL-4: Develop Modeling and Monitoring Program

MBNMS will work with partners to develop a comprehensive modeling and monitoring program to determine predicted properties of brine plume and measure short-term, long-term, and cumulative impacts. The program will include information requirements for parties seeking permits, as well as a multi-tiered modeling and monitoring program. This multi-tiered approach includes identifying different levels of requirements based on characteristics of a proposed facility such as its location, the biological sensitivity of the habitat near its intake and outfall, specific properties of the brine discharge plume, and other characteristics.

Activity 4.1: Establish Regional Modeling Guidelines

MBNMS staff will coordinate with partners to establish and implement regional guidelines for modeling of expected brine effluent plumes by evaluating accuracy of existing plume and circulation models applied to desalination, including field testing, if necessary, and identifying acceptable models.

Activity 4.2: Identify Submittal Information Required for Project Application

MBNMS staff will coordinate with the appropriate regulatory agencies to identify the minimum requirements for the standard information submitted by the applicant for any proposed facilities seeking permits. These should include:

A. Initial evaluation of recreational, public use, and commercial impacts in vicinity of desalination facility
B. Initial monitoring to determine currents, tides, water depth and similar parameters of receiving waters
C. Pre-construction biological analysis, with consideration of seasonal variability, of marine organisms in the affected area and control site to include indices, species richness, and abundance, along with evaluation of entrainment and impingement impacts
D. Pre-construction estimation of expected brine composition, volumes, and dilution rates of the brine in the zone of initial dilution
E. Plan for toxicity testing of the whole effluent as an ongoing monitoring requirement
F. Studies to determine properties of combined discharges (cooling water or sewage), and their effects and toxicity on local species

G. Post-operational monitoring of salinity in zone of initial dilution and control site, as an indicator for plume spreading and dispersal, to be compared with expected results from plume and circulation modeling; if not in compliance, then identify and implement corrective actions
H. End of pipe monitoring program to verify results from expected brine composition and dilution
I. Facility plans, and anticipated operations and management plans, including identification of potential land and water use implications stemming from plans to ensure public safety against possible hostile actions

Activity 4.3: Identify Additional Submittal Requirements for Projects in Sensitive Areas
Staff will coordinate with the appropriate regulatory agencies to identify additional requirements for those proposed facilities that may affect sensitive habitats or may have increased or significant impacts on coastal resources. Based upon sensitivity of habitat in vicinity of the discharge and size of zone of initial dilution, additional requirements may include:

A. Pre-construction monitoring of affected area as well as a control site to include sampling of water column and sediments
B. Post operational monitoring of affected area as well as a control site, to include sampling of water column and sediments, to be compared with pre-operational monitoring results
C. Post operational monitoring of oxygen levels, turbidity, heavy metals or other chemical concentrations with regard to water quality standards
D. Post operational sampling of sediments for heavy metals to monitor possible accumulation (possible bio-monitoring to sample tissues for heavy metals)
E. Post operational biological analysis of marine organisms in the affected area and control site, including indices, species richness, and abundance to be compared with the pre-operational results
F. Monitoring of long-term impacts of discharge (e.g. potential changes in species composition etc.)

Activity 4.4: Coordinate Enforcement and Permit Compliance
The MBNMS will coordinate with state partners to evaluate permitted desalination facilities and follow up to ensure compliance with conditions of permits and authorizations.

Activity 4.5: Determine Cumulative Impacts from Multiple Facilities
MBNMS staff will coordinate with partners and other agencies to develop and implement a regional monitoring program to evaluate cumulative impacts from multiple facilities, including methods to assess impacts of saline brine effluent and cumulative entrainment and impingement.

Strategy DESAL-5: Conduct Outreach and Information Exchange

Extensive outreach on the guidelines and recommendations developed by this working group will be conducted.

Activity 5.1: Continue Participation in Other Desalination Initiatives

MBNMS staff will continue to participate in other desalination initiatives, including state and federal task forces and workgroups, and will actively seek to include the information and relevant recommendations resulting from those efforts into this action plan, as appropriate.

Activity 5.2: Develop Outreach Plan for MBNMS Desalination Guidelines and Regulations

MBNMS staff will develop and implement a program for outreach to agencies, desalination plant proponents, and other interested parties about the guidelines as well as relevant regulations.

Activity 5.3: Develop Outreach Plan for Information about Desalination Issues

MBNMS will coordinate with partners to develop and implement strategies for ongoing outreach to the public and agencies regarding desalination projects, issues, and potential impacts to MBNMS resources.

Activity 5.4: Track and Evaluate Emerging Desalination Technology

MBNMS staff will develop a program to track and evaluate new and emerging desalination technologies, and a system to incorporate these into existing and proposed plants.

Activity 5.5: Conduct Community Growth Impact Outreach

MBNMS staff will work with partners to share information and concerns with agencies and local jurisdictions about the potential impacts of community growth to MBNMS resources.

Action Plan Partners: California Coastal Commission, Central Coast Regional Water Quality Control Board, State Water Resources Control Board, local jurisdictions, counties, land use and environmental organizations, California Department of Fish and Game, Scientific consultation, C-Clean monitoring project, Elkhorn Slough National Estuarine Research Reserve

Table DESAL.1: Measuring Performance of the Desalination Action Plan

Desired Outcome(s) For This Action Plan:	
Minimize entrainment, concentrated discharges and impacts to the seabed from desalination facility construction and operation.	
Performance Measure	**Explanation**
100% of new desalination plants permitted in the MBNMS have been reviewed in a coordinated regional approach and constructed consistent with MBNMS siting guidelines and environmental standards for intakes and outfalls.	MBNMS will track the review of new facility applications and determine the number of projects reviewed in a coordinated regional approach.

Table DESAL.2: Estimated Timelines for the Desalination Action Plan

Desalination Action Plan	YR 1	YR 2	YR 3	YR 4	YR 5
Strategy DESAL-1: Develop and Implement Regional Desalination Program					
Strategy DESAL-2: Develop Facility Siting Guidelines					
Strategy DESAL-3: Identify Environmental Standards for Desalination Facilities					
Strategy DESAL-4: Develop Modeling and Monitoring Program					
Strategy DESAL-5: Conduct Outreach and Information Exchange					

Legend	
Year Beginning/Ending :	Major Level of Implementation:
Ongoing Strategy :	Minor Level of Implementation:

Table DESAL.3: Estimated Costs for the Desalination Action Plan

Strategy	Estimated Annual Cost (in thousands)*				
	YR 1	YR 2	YR 3	YR 4	YR 5
Strategy DESAL-1: Develop and Implement Regional Desalination Program	$24	$25	$21	$9	$8
Strategy DESAL-2: Develop Facility Siting Guidelines	$20	$20	$4	$0	$0
Strategy DESAL-3: Identify Environmental Standards for Desalination Facilities	$16	$16	$4	$0	$0
Strategy DESAL-4: Develop Modeling and Monitoring Program	$8	$284.4	$29.8	$176.4	$0
Strategy DESAL-5: Conduct Outreach and Information Exchange	$31.5	$59.5	$15.5	$13	$9
Total Estimated Annual Cost	*$99.5*	*$404.9*	*$74.3*	*$198.4*	*$17*

* Cost estimates are for both “programmatic” and “base” (salaries and overhead) expenses.

Harbors and Dredge Disposal Action Plan

Goal

Address the need for disposal of dredged material and the continued protection of MBNMS resources and qualities.

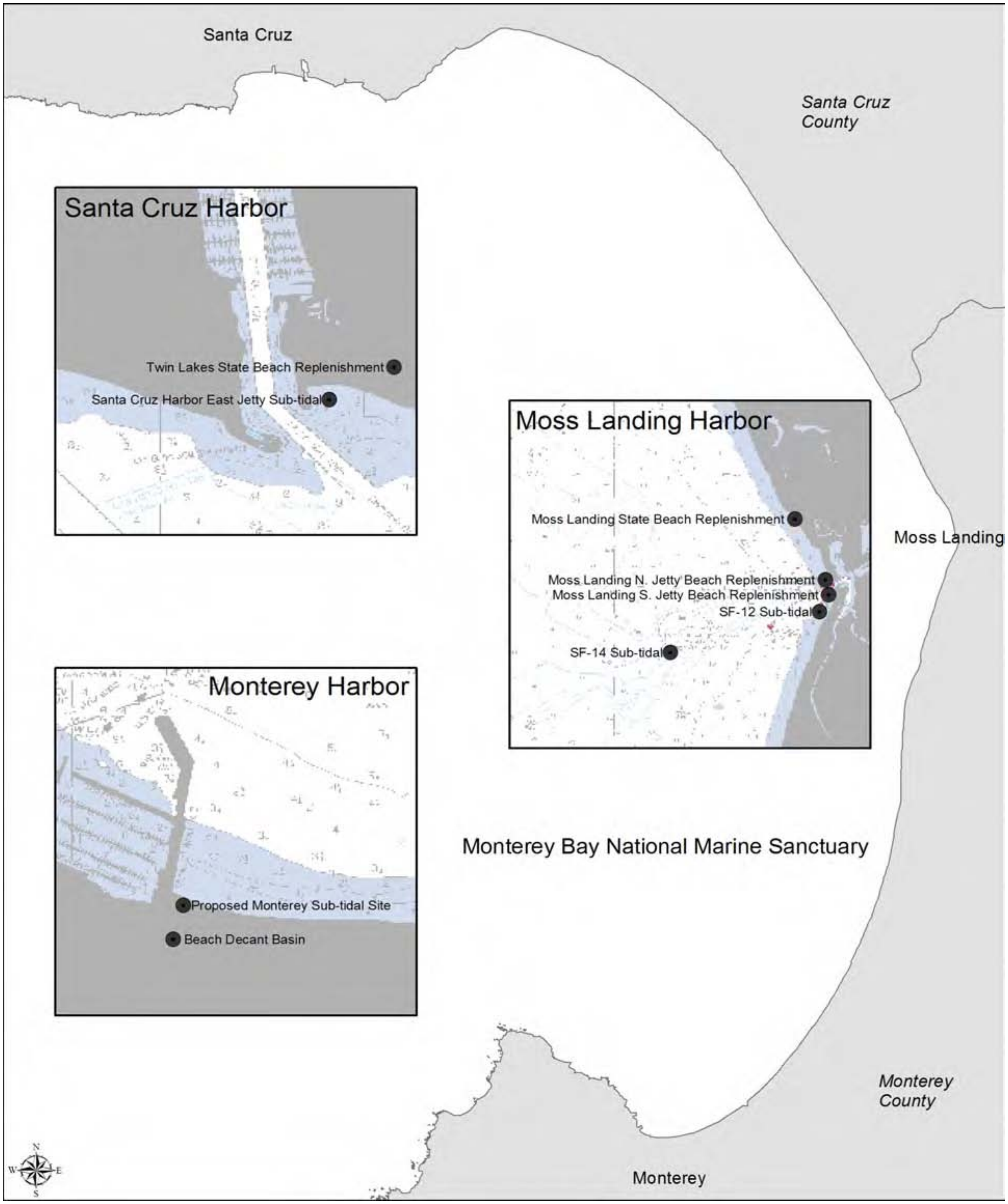
Figure HDD-1 – Moss Landing Harbor

Introduction

There are four major harbors adjacent to the Monterey Bay National Marine Sanctuary (MBNMS): Pillar Point, Santa Cruz, Moss Landing and Monterey (See Figure HDD-2). The periodic dredging of the local harbors is a necessary component of keeping the harbor channels clear and allowing access for vessels. Dredging generally occurs within a port or harbor and therefore outside of MBNMS boundaries. Santa Cruz and Moss Landing regularly dredge the bottom of the harbor. Harbors dispose of their dredged material either in the ocean, on land at landfill sites, or at designated beach nourishment sites adjacent to the harbors. When the MBNMS was designated in 1992, two existing offshore sites for dredge disposal were identified, and the establishment of new sites was prohibited within its boundaries. While dredging itself, within the confines of harbors, is not prohibited by MBNMS regulation, disposal of dredged materail is prohibited within the MBNMS except for dredged material deposited at authorized disposal sites.

The MBNMS works with other state and federal agencies to ensure that MBNMS resources are protected during dredge disposal. The MBNMS coordinates with the California Coastal Commission, the US Army Corps of Engineers (ACOE), Environmental Protection Agency (EPA), the Regional Water Quality Control Board (RWQCB), California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), and the US Fish and Wildlife Service (FWS) to review and authorize dredge disposal, as well as other discharges within the MBNMS. The MBNMS reviews the composition of the sediment, volumes, grain size, and associated contaminant load to determine if the dredge sediments are appropriate for disposal in the ocean and comply with the provisions of the NMSA.

Figure HDD-2. Harbors and Dredge Disposal Sites



Strategy HDD-1: Improve Agency Coordination

The MBNMS will continue to authorize, as appropriate, other agency's permits for dredge disposal and consider improving the interagency review process.

Activity 1.1: Continue to Improve and Participate in Coordinated Permit Review

Increased efficiency, collaboration and coordination are necessary in the review of permits for dredge disposal. The MBNMS will continue to coordinate with the Coastal Commission, ACOE, and EPA to review permits and authorizations. The MBNMS will work collaboratively with others to establish an interagency Central Coast Dredge Team that would meet at regular intervals and develop a regional plan to:

A. Improve understanding of joint agency roles
B. Encourage harbors to undertake advanced planning and coordination that may minimize the need for emergency permits
C. Schedule permit planning meetings with agencies and harbors in advance of the application process to address needs and collectively evaluate both the regular and emergency permit process, to include agency concerns and conditions in the permit
D. Evaluate other joint-permit programs
E. Where possible, align agency permits so each permit or authorization is valid for the same time interval
F. Evaluate changes to dredge disposal practices, methods, and operations to benefit the resources, such as timing disposal events with winter storms, changing the methodology to increase oxygen levels or adding an additional pipe, where appropriate, or attempt to mimic natural sedimentation processes

Activity 1.2: Issue Multi-year Authorizations for Dredge Disposal Activities

The authorization intervals may be increased to provide efficiency for both the harbor as well as the MBNMS. MBNMS will work with partners to coordinate the timing and conditions of the multi-year permit process. The MBNMS will also work with partners to evaluate multi-year authorizations and the conditions of the authorizations to include additional testing, or sampling and monitoring requirements as necessary.

Activity 1.3: Enforcement and Permit Compliance

The MBNMS will coordinate with partners to monitor dredge activities and follow up to ensure compliance with conditions of permits and authorizations.

Strategy HDD-2: Review Offshore Dredge Disposal Activities

MBNMS recognizes four sites as approved for disposal of dredged material including SF-12, SF-14, and limited disposal sites at Monterey and Santa Cruz Harbor. MBNMS will review and process permit applications for these sites consistent with these locations. Further analysis of additional sites or modifications to existing sites may occur as necessary; however, a modification to the Designation Document and regulations would be required to allow dredged material to be deposited at a disposal site not authorized prior to January 1, 1993.

Activity 2.1: Review Santa Cruz Dredge Disposal Activities

MBNMS will continue to work with its partners and the Santa Cruz Port District in reviewing proposals to dispose of dredged material at the Twin Lakes Disposal Site adjacent to the harbor entrance. The MBNMS will also coordinate with partners in reviewing future applications to modify the disposal area or location.

Activity 2.2: Review Dredge Disposal Activities at Monterey Harbor

MBNMS staff will continue to work with its partners and the City of Monterey in reviewing proposals to dispose of dredged material at its site adjacent to Wharf 2, adjacent to the harbor.

Activity 2.3: Review Dredge Disposal Activities at Redefined SF-12 (Moss Landing)

MBNMS staff will continue to work with its agency partners including the Environmental Protection Agency, Army Corps of Engineers, and California Coastal Commission in reviewing proposals to dispose of dredged material at EPA Dredge Disposal Site SF-12. Proposals will utilize the redefined location of SF-12 adopted in 2005 to ensure disposal of dredged material at the head of the Monterey Canyon.

Activity 2.4: Coordinate with Gulf of the Farallones National Marine Sanctuary (GFNMS) in Evaluation of Dredge Disposal Site for Pillar Point Harbor

The Pillar Point Harbor has not been dredged since the 1980's when the inner harbor was created. The harbor is considering dredging the outer and inner harbor areas to eliminate sedimentation that has accumulated. The estimated volume of this project would be approximately 72,000 cubic yards for the maintenance-dredging component. Upon submission of a project application, MBNMS will coordinate with the GFNMS to evaluate options for allowing maintenance of this local harbor disposal. MBNMS will also coordinate with GFNMS to explore ways to better manage dredging needs as identified in Strategy HDD-3. Any addition of dredge disposal sites to the MBNMS would require modifications to the regulations and Designation Document.

Strategy HDD-3: Coordinate with Sediment Monitoring and Reduction Programs

This strategy recognizes the need to track and evaluate the call for increased disposal volumes, identify areas where improvements could be made to reduce increased sedimentation in harbors, evaluate contamination levels and sources, and conduct research to minimize information gaps.

Activity 3.1: Assess Changes in Aquatic Disposal Volumes

Harbors abutting the MBNMS have applied for and received significant increases in the permit volume of dredge disposal sediments over the past ten years. The Santa Cruz Harbor has increased its allowable permit volume by greater than 275 percent of the disposal quantity identified at the time of MBNMS designation. The Moss Landing Harbor has increased its allowable permit volume by 100 percent since MBNMS designation. In both instances, the MBNMS has authorized these increases. There are currently information gaps as to why this permitted increase is needed. MBNMS will work with the EPA, ACOE and harbors to develop an interagency database for tracking volumes and sediment types while facilitating submittal of electronic data, increase accessibility for the public via a website, and work with others to promote monitoring at designated disposal sites to establish and evaluate long-term trends and related habitat and biological impacts from increased volumes.

Activity 3.2: Coordinate with Sediment Reduction Programs

In order to reduce the amount of material dredged from harbors, the MBNMS will encourage reduction of the amount of sediment entering the harbors by evaluating the watershed as a whole to determine where sediment reduction efforts could be implemented. MBNMS will work with partners to promote retention of sediment in the watershed. The MBNMS will continue to encourage these efforts with the agricultural and rural community as part of the MBNMS Agriculture and Rural Lands Plan, which encourages farmers, ranchers, and rural landowners to use conservation practices on their properties to reduce runoff in the form of sediments, nutrients and pesticides. The MBNMS will also work with others to prevent urban runoff and sedimentation into the watersheds. The MBNMS will also work with partners to explore tools to reduce entrapment of sediments by harbors, breakwaters, and other structures.

Activity 3.3: Address Dredge Sediments Contamination

Contamination is typically associated with fine-grain sediment where higher sand contents and larger grain sizes are relatively free of contamination. The physical characteristics of the sediment play a role in the strength of chemical adsorption and the active surface area of the particles. Contamination is a particularly acute problem in the sediments at Moss Landing. MBNMS will encourage partners to coordinate with the MBNMS Water Quality Protection Program to identify the upland sources of contaminated sediment and actively manage contamination, including pesticides, biological contaminants, PCB's, Butyltins, DDT, and other pollutants.

Activity 3.4: Coastal and Estuarine Erosion and Sediment Flow

In coordination with implementation of the Coastal Armoring Action Plan, the MBNMS will encourage partners to analyze coastal and estuarine erosion associated with harbor dredging and dredge disposal and to further characterize sediment flow. Further monitoring of dredging and disposal activities must be associated with future projects to evaluate the fate of sediments at Santa Cruz Harbor and Moss Landing Harbor and to evaluate potential exacerbation of tidal scour in Elkhorn Slough associated with dredging of Moss Landing Harbor.

Strategy HDD-4: Disposal of Fine-Grained Material

The disposal of fine-grained material is authorized at SF-12 and SF-14 and on a limited basis at the Santa Cruz Harbor/Twin Lakes disposal site. When determining if material is suitable for intertidal and subtidal disposal on local beaches adjacent to the harbors, EPA guidelines state that material for disposal must be at least 80 percent sand.

Activity 4.1: Continue to Evaluate Grain Sizes of Dredged Material

MBNMS will continue to coordinate with EPA/ACOE to evaluate sediment disposal suitability and coordinate on any project that would vary from EPA national guidelines on a case-by-case basis. The MBNMS will analyze any variances from those guidelines to ensure adequate protection of MBNMS resources and qualities and coordinate with other agencies to determine criteria for disposing dredged material that is less than 80 percent sand.

Strategy HDD-5: Alternative Disposal Methods

Approximately 98 percent of harbor sediments appropriate for unconfined aquatic disposal have been authorized by the MBNMS for disposal in the marine environment. Occasionally, there may be other uses for dredged sediments that meet standards for the given beneficial use. The Santa Cruz Harbor and the Moss Landing Harbor both have areas adjacent to the harbors that have been designated as beach nourishment sites. Both harbors dispose dredged material below mean high water at those locations. Two additional areas at Moss Landing (Zmudowski Beach and the north jetty) are deemed beach nourishment sites. These sites are above mean high water and therefore outside of the MBNMS. These sites are not authorized by the MBNMS for subtidal disposal. Disposal at Zmudowski Beach and the north jetty has not taken place since MBNMS designation. Any future disposal there would need to be accomplished above mean high water. At this time there does not seem to be a need for additional beach nourishment sites within the MBNMS, except for possibly at Pillar Point Harbor. However, the MBNMS will work together with other state and federal agencies to evaluate the potential future need for beach nourishment at locations within the Sanctuary and will collaborate with other agencies to conduct long-term planning and analysis related to this issue.

Activity 5.1: Evaluate Potential Beneficial Use of Dredged Materials

MBNMS will work with partners to examine the potential beneficial uses for dredged material. Recognizing that littoral sand is a MBNMS resource for various habitat, recreation, access and shoreline protection reasons, MBNMS and other agencies should identify if, when and where beach nourishment is appropriate. As discussed in the Coastal Armoring Action, MBNMS may identify the criteria and data needed to make that determination, including an evaluation of sand transport and science needs and pursuit of a comprehensive research strategy. In addition, MBNMS will work with partners to assess individual and cumulative impacts to sand transport and shoreline dynamics due to existing harbors and artificial groins within the MBNMS. Studies should estimate the quantity of sand and sand-generating beach material that is trapped by such structures and assess means to bypass such material and replicate natural processes to the degree feasible. If investigations indicate that employment of additional beach nourishment sites using clean dredged harbor material would be possible and appropriate, MBNMS may examine whether revision of MBNMS regulations and Designation Document may be warranted; or if a beneficial program might occur via MBNMS permit or authorization in concert with other agencies.

Action Plan Partners: California Coastal Commission, US Army Corps of Engineers, Environmental Protection Agency, Regional Water Quality Control Board, California Department of Fish and Game, National Marine Fisheries Service, US Fish and Wildlife Service, Santa Cruz Port District, City of Monterey, Moss Landing Harbor District, San Mateo County Harbor District, Santa Cruz Harbor District, City of Santa Cruz

Table HDD.1: Measuring Performance of the Harbors and Dredge Disposal Action Plan

Desired Outcome(s) For This Action Plan:	
Increase interagency coordination to ensure protection of MBNMS resources while allowing harbors to remain open for navigation.	
Performance Measure	**Explanation**
By 2012, dredge disposal permits will be authorized for the same duration among the EPA, CCC, ACOE, and MBNMS, where appropriate.	MBNMS staff will work with the various agencies to align the permitting of dredging and disposal of material where appropriate in the four approved sites in the MBNMS.

Table HDD.2: Estimated Timelines for the Harbors and Dredge Disposal Action Plan

Harbors and Dredge Disposal Action Plan	**YR 1**	**YR 2**	**YR 3**	**YR 4**	**YR 5**
Strategy HDD-1: Improve Agency Coordination	●——	——●			
Strategy HDD-2: Review Offshore Dredge Disposal Activities	●——	——●			
Strategy HDD-3: Coordinate with Sediment Monitoring and Reduction Program			●——	————	——▶
Strategy HDD-4: Disposal of Fine-Grained Material			●——	——●	
StrategyHDD-5: Alternative Disposal Methods			●——	——●	

Legend	
Year Beginning/Ending : ●——●	Major Level of Implementation: ————
Ongoing Strategy : ●——▶	Minor Level of Implementation: ....

Table HDD.3: Estimated Costs for the Harbors and Dredge Disposal Action Plan

Strategy	**Estimated Annual Cost (in thousands)***				
	YR 1	**YR 2**	**YR 3**	**YR 4**	**YR 5**
Strategy HDD-1: Improve Agency Coordination	$14	$14	$5	$5	$5
Strategy HDD-2: Review Offshore Dredge Disposal Activities	$33.8	$20	$4	$4	$0
Strategy HDD-3: Coordinate with Sediment Monitoring and Reduction Program	$16	$122.9	$18.9	$14.9	$14.9
Strategy HDD-4: Disposal of Fine-Grained Material	$8	$0	$0	$0	$0
StrategyHDD-5: Alternative Disposal Methods	$0	$0	$25.2	$25.2	$25.2
Total Estimated Annual Cost	*$71.8*	*$156.9*	*$53.1*	*$49.1*	*$45.1*

* Cost estimates are for both “programmatic” and “base” (salaries and overhead) expenses.

Submerged Cables Action Plan

Goal

Provide clear guidance regarding installation, operation, or removal of submerged cables to protect the resources and qualities of the MBNMS.

Introduction

Installation of submerged cables in the MBNMS alters the seabed, causing environmental impacts and potential hazards for fishing activities. Submerged cables are typically used for commercial, defense or research related activities. MBNMS regulations currently prohibit alteration of the seabed, yet allow, via permit or authorization, for some otherwise prohibited activities.

MBNMS regulations in effect prohibit the installation of submerged cables. Such regulatory prohibitions include those against: drilling into, dredging or otherwise altering the seabed of the MBNMS; constructing, placing or abandoning any structure, material or other matter on the seabed of the MBNMS; moving or injuring historical resources; and discharging or depositing any material or other matter in the MBNMS. Therefore, installing submerged cables would involve violations of MBNMS prohibitions. The NMSA prohibits destroying, causing the loss of, or injuring any MBNMS resource managed under law or regulations for that Sanctuary. Prohibited activities may be conducted under certain limited circumstances to the extent they are compatible with the resource protection mandate and meet regulatory and other requirements for a MBNMS permit or other authorization.

Currently submerged cable applications are reviewed on a case-by-case basis. Policy guidance for future applicants would provide for a more efficient permitting process and inform future applicants as to preferred alternatives prior to submitting an application. In 1999, due to expanding interest in constructing submerged telecommunications cables in national marine sanctuaries, including the MBNMS, the National Marine Sanctuaries Program (NMSP) initiated a process to consider guidance for cable projects proposed for national marine sanctuaries. Also, there has been a recent increase in interest to develop cabled observatories nationwide for research and monitoring purposes, including in the MBNMS. In implementation of this action plan, the MBNMS will develop a framework to identify sensitive areas of the seafloor within the MBNMS and provide clear structure with which to review future submerged cable development applications.

MBNMS regulations recognize certain activities that may benefit the MBNMS, such as education, research, or management; thus a submerged cable that provides these benefits could be permitted under existing regulations. A proposed research cable project must demonstrate the benefit that it would provide to MBNMS, as well as that the project would have only negligible, short-term, adverse effects on Sanctuary resources and qualities. In deciding whether to issue a permit, the Superintendent shall consider such factors as: the professional qualifications and financial ability of the applicant as related to the proposed activity, the duration of the activity, and the duration of its effects; and the appropriateness of the methods and procedures proposed by the applicant for the conduct of the activity. In addition, the Superintendent may consider other factors, as he or she deems appropriate.

The MBNMS may allow construction and operation of a cable for commercial purposes, such as a trans-ocean fiber optic cable. The MBNMS may issue a Special Use permit to allow specific activities in the MBNMS if such authorization is necessary to establish conditions of access to and use of any MBNMS resource. A commercial submerged cable project's continued presence on the seabed during operation is considered a special use. (Special Use Permits may be issued for the narrow range of activities that are both prohibited by NMSP regulations and will result in no adverse effect to the MBNMS resource or qualities, and thus, must meet a higher standard than other categories of permits.) The MBNMS does not consider intrusive activities related to commercial submarine cables such as installation, removal, and maintenance/repair work to qualify for a Special Use permit. Those activities would require a permit or an authorization of another agency's permit. These authorizations, if approved, generally include a variety of conditions to minimize impacts to MBNMS resources and qualities.

The NMSA requires that Special Use permits shall:

A. Authorize the conduct of an activity only if that activity is compatible with the purposes for which the MBNMS is designated and with protection of MBNMS resources
B. Not authorize the conduct of any activity for a period of more than five years
C. Require that activities carried out under the permit be conducted in a manner that does not destroy, cause the loss of, or injure MBNMS resources
D. Require the permittee to purchase and maintain comprehensive general liability insurance, or post an equivalent bond, against claims arising out of activities conducted under the permit and to agree to hold the United States harmless against such claims

Existing Submerged Cables in MBNMS

Projects that include submerged cables for research, military and commercial uses are already in place within MBNMS. Known cables include:

A. San Francisco-Honolulu 1903 telegraph cable, decommissioned
B. Pioneer Seamount Cable (formerly Acoustic Thermometry of Ocean Climate (ATOC)), presently under the responsibility of the National Oceanic and Atmospheric Administration (NOAA) Oceanic and Atmospheric Research Division, used for passive acoustic research, http://oceanexplorer.noaa.gov/explorations/sound01/sound01.html
C. Pt. Sur cable, U.S. Navy, used for research
D. Monterey Inter-Shelf Observatory (MISO) cable, owned and operated by the Naval Postgraduate School for oceanographic research, www.oc.nps.navy.mil/~stanton/miso/
E. Orpheus, National Marine Sanctuaries Program, video link to the Mystic Aquarium and Institute for Exploration, http://www.mysticaquarium.org/index.cgi/1670
F. Monterey Acoustic Research System (MARS) Cable, Monterey Bay Aquarium Research Institute, http://www.mbari.org
G. Unknown coaxial cable, near ATOC cable

Strategy SC-1: Identify Routing and Zones for Submerged Cable Projects

The MBNMS recommends keeping submerged cables out of special management areas such as national marine sanctuaries and state marine protected areas. The MBNMS exercises a precautionary, comprehensive approach to installation of cables in the MBNMS. Before permitting any installation of a cable, the MBNMS will consult with the affected state and federal agencies and interested persons to determine the route which best meets the MBNMS requirements.

Activity 1.1: Identify Environmentally Sensitive Areas

The MBNMS will develop, and update annually as more refined data become available, Geographic Information System (GIS) data layers of environmentally sensitive habitat areas on a broad, MBNMS-wide scale, using the best available data. The MBNMS's permitting staff will use this data as a guide to identify areas to avoid, as well as potential cable laying regions. Initially this map will include fragile habitats, known archaeological sites, and other areas of concern:

A. High-relief rocky substrate and other hard bottom areas
B. Sea grass communities
C. Areas known or likely to have maritime heritage resources
D. Kelp forests
E. Critical habitat for endangered or threatened species
F. Areas set aside as state or federal marine protected areas
G. Known spawning aggregation areas
H. Estuarine habitats
I. Essential Fish Habitat
J. Cold seep communities
K. Marine trenches, valleys or canyons, regarding the likelihood of (a) cable breakage and resulting repair impacts and (b) suspensions and resulting entanglement risk

The map will also include:

A. All known cables in the MBNMS, active, inactive and stored
B. Other known structures, such as pipelines, outfalls, and buoys
C. Known research sites where cable construction would interfere with the research
D. Location of present and historic trawling areas within the MBNMS
E. Characterization of the coast and landfalls (e.g. cliffs, dunes, sediment type)

This database system should become integrated with Sanctuary Integrated Monitoring Network (SIMoN) to facilitate use by other agencies and the public.

Activity 1.2: Develop Guidelines for Siting Constraints for Submerged Cables

Submerged cables will generally not be permitted in the environmentally sensitive habitat areas. However, the MBNMS may allow submerged cables to be built into or through these areas where they will have clear and demonstrable resource management, research, and/or educational value.

A. The MBNMS may set restrictions for the number of cables that will be allowed in certain areas, as “corridors” for future cables. This is designed to establish clearer guidance for future cable applicants and more predictability about future routing of cables.
B. The MBNMS will produce these guidelines after completing Activity 1.1 and consulting with interested parties and stakeholders.

These guidelines would be considered a work in progress, to be updated by MBNMS annually. MBNMS will continue to work to improve the level of understanding and knowledge about the laying and operation of submarine cables. As new information and technology develops, the policies and permit requirements and conditions will evolve accordingly.

Strategy SC-2: Develop Submerged Cable Project Permit Guidelines

MBNMS regulatory prohibitions require issuance of a permit or authorization before any proposed submerged cable project can be built. If the MBNMS decides to allow a cable projct, it may impose terms and conditions on such authorization consistent with the purposes for which the MBNMS is designated.

Activity 2.1: Refine and Implement Permit Pathway and Applicant Guidelines

The following steps in the permit and application process will be refined and/or implemented.

A. *Permit Process*
The MBNMS has distinct authorities to allow for the conduct of specific prohibited activities, such as cable installation, within national marine sanctuaries. The most commonly used authority is found in NMSP regulations (15CFR Part 922) to allow certain types of activities, such as, research, education and resource management, to occur in instances where it would otherwise be prohibited by the NMSP regulations. In addition NMSP regulations also allow “authorization” of other-agency permits for prohibited activities that do not qualify for a research or other permit. The other authority derives from Section 310 of the NMSA. This authority, named “special use permits” by the statute, is generally used for commercial activities requiring access to or use of sanctuary resources, whereas research permits are issued for bona fide research activities. The installation, maintenance, or removal of the cable would require a permit or an authorization, whereas the continued presence of a commercial cable could be permitted in appropriate circumstances with a Special Use Permit. Permits would be required by MBNMS for the following activities related to submerged cables:
B. Discharging or depositing, from within the boundary of the MBNMS, any material or other matter

Drilling into, dredging or otherwise altering the seabed of the MBNMS; or constructing, placing or abandoning any structure, material or other matter on the seabed of the MBNMS

Taking any marine mammal, sea turtle or seabird in or above the MBNMS

C. *Project Description*
The project applicant initially provides a complete and thorough application in order to facilitate the permit process. Specifics and detail enable MBNMS permitting staff to evaluate the proposed project more quickly.
D. *Site Characterization and pre-construction surveys*
Biological, cultural and habitat surveys along the proposed and alternative cable routes must be completed in advance by the project applicant. Project applicants may be required to collect baseline data in order to properly assess post-deployment impacts.

The site characterization shall include the percent of the route where the cable can be buried and expect to remain buried over the cable lifetime. This characterization should also include penetration depths of bottom fishing activities and expected anchor penetration depths of vessels using the area. Other factors such as wave energy intensity, bottom current strength, seasonal sand/sediment movement, coastal erosion rates of the shore landing relative to the cable project's life, landslide and other geological hazards should also be addressed.

E. *National Environmental Policy Act (NEPA) Review and Interagency Cooperation*
MBNMS will coordinate with other federal and state agencies throughout the permitting process. MBNMS will usually act as a Federal Lead Agency in the NEPA process, and as such will work with the State Lead Agency to produce a joint NEPA/CEQA document. For every project considered, the environmental impact analysis must evaluate, at a minimum, the following topics:

Potential cumulative impacts

Feasible alternatives to transiting MBNMS, including alternative routes over land

Potential impacts to habitat from laying the cable (e.g., trenching) and long-term placement of the cable in its location

Potential for impacts on sensitive, threatened and endangered species and their habitats

Potential impact on submerged cultural resources, and traditional cultural uses

Potential impacts of removing the cable at the end of its useful life

Potential socioeconomic impacts (e.g., fishing interests, ecotourism, etc.)

Activity 2.2: Identify Development Standards

MBNMS staff will identify development standards for the following issues:

A. *Cable Laying, Installation and Burial*
Required burial depth and preferred cable laying techniques will be identified. Cables shall be buried to a depth pre-determined by the project applicant and approved by the MBNMS Superintendent. Optimal burial depth is specific to site, other human uses, and bottom type. It accounts for the uses of seabed, including the cable, and is required to be at a depth sufficient to avoid conflicts with other ocean users and industries. Optimal burial depth also ensures that the natural sediment conditions will not unbury the cable with time. The project applicant shall also use the best available proven technology to bury the cable and to alleviate the potential for strumming when passing through rocky habitats. MBNMS will develop criteria to determine the preferred method of installation for a new conduit in a given location.

B. *Onshore Landing and Drilling*
All proposed sites for shore crossings and cable landings must first consider using any pre-existing available onshore conduits. If there are no pre-existing conduits, or available conduits do not suit the project, then a new conduit may be proposed. Additionally, proposed sites for shore crossings and cable landings must first consider utilizing co-landings or the installation of more than one cable in a single conduit through the nearshore environment. The use of co-landings would minimize the potential impacts associated with directional drilling or beach trenching operations.

C. *Cable Removal*
MBNMS regulations prohibit "drilling into, dredging, or otherwise altering the seabed of the MBNMS, or constructing, placing or abandoning any structure, material or other matter on the seabed of the MBNMS." Therefore, per the regulations, the project applicant must remove all of the cable within MBNMS at the termination of the cable project. Upon the conclusion of the cable project, MBNMS may support the transfer of a cable to a new project applicant, provided that applicant is granted the necessary MBNMS permits. Permit review for a transfer would include a cable integrity analysis to evaluate the status and expected future viability of the cable and other information as required by MBNMS. New project applicants would have to agree to all existing terms of existing permits or authorizations, including cable removal. Storage of cable offshore, within the MBNMS boundary, would not be allowed.

D. *Cable Monitoring*
A monitoring strategy will be developed for both post-construction and for the life of the project. The project applicant will be required to monitor the cable throughout its permitted life for cable integrity, burial depth and its effects on the benthos. The feasibility of monitoring may be challenging and the costs associated with monitoring are likely to be high. MBNMS may also choose to monitor the cable, and if so, will notify the cable applicant and provide it with the results of the survey.

Activity 2.3: Identify Standard Permit Conditions

In addition to developing a list of general and special permit conditions, MBNMS will work with other agencies to develop a comprehensive list of all permit requirements for submerged cable projects.

Activity 2.4: Consider Standard Fee Structure for Submerged Cable Continued Presence on Seafloor and Operation

MBNMS staff will consider a Special Use Permit standard fee structure for monitoring and operation of submerged cables within the MBNMS. Special Use Permits can be issued for appropriate commercial activities that require access to and use of any MBNMS resource. Pursuant to the NMSA, a fee may be assessed for any approved commercial submerged cable project. This fee includes:

A. The costs incurred, or expected to be incurred by MBNMS, to issue the permit (including labor, printing costs, and contracts for the preparation of supporting documentation). The MBNMS Superintendent would provide a cost estimate once a project is defined. However, if additional environmental studies are required by MBNMS, the applicant is responsible for study costs.

B. The costs incurred, or expected to be incurred by MBNMS, as a direct result of the conduct of the activity for which the permit is issued, including the costs of monitoring the conduct of the activity (includes amounts to fund monitoring projects designed to assess the success or failure of the permittee to comply with the terms and conditions of the permit. Costs may also include money to fund a compliance monitoring program and to recoup any costs incurred by the NMSP in enforcing permit terms and conditions). These costs on existing projects tend to be very high due to the challenging nature of monitoring a project on the ocean floor.

C. An amount that represents the fair market value of the use of the MBNMS resource (calculated using economic valuation methods appropriate to the situation).

MBNMS will require the project applicant to post a bond to cover the costs of negative impacts resulting from the cables, to ensure permit condition compliance, and to provide for cable removal.

Activity 2.5: Enforcement and Permit Compliance

The MBNMS will inspect and evaluate permitted cable activities including cable laying, maintenance and removal, and follow up to ensure that permit conditions are met.

Action Plan Partners: National Marine Fisheries Service, California Department of Fish and Game, California Coastal Commission, California State Lands Commission

Table SC.1: Measuring Performance of the Submerged Cables Action Plan

Desired Outcome(s) For This Action Plan**:**	
To minimize impacts to MBNMS seafloor and habitats from installation, maintenance and removal of submerged cables.	
Performance Measure	**Explanation**
By 2009, complete mapping of best available data on sensitive areas to avoid for cable routes.	Performance toward meeting the objectives can be measured incrementally by identifying the amount of mapping that has been gathered, identified as sensitive and made available to the public.
By 2010, identify standard interagency list of permit conditions to minimize disturbance of sensitive habitats.	Staff will also track the development of permit conditions that will provide the public and applicant an understanding of standard requirements prior to project application.

Table SC.2: Estimated Timelines for the Submerged Cables Action Plan

Submerged Cables Action Plan	YR 1	YR 2	YR 3	YR 4	YR 5
Strategy SC-1: Identify Routing and Zones for Submerged Cable Projects	●———	———●			
Strategy SC-2: Develop Submerged Cable Project Permit Guidelines	●———	———●			

Legend	
Year Beginning/Ending : ●———●	Major Level of Implementation: ———
Ongoing Strategy : ●———▶	Minor Level of Implementation: ....

Table SC.3: Estimated Costs for the Submerged Cables Action Plan

Strategy	**Estimated Annual Cost (in thousands)***				
	YR 1	**YR 2**	**YR 3**	**YR 4**	**YR 5**
Strategy SC-1: Identify Routing and Zones for Submerged Cable Projects	$56	$115	$101	$4	$4
Strategy SC-2: Develop Submerged Cable Project Permit Guidelines	$27	$13	$11	$4	$4
Total Estimated Annual Cost	*$83*	*$128*	*$112*	*$8*	*$8*
* Cost estimates are for both "programmatic" and "base" (salaries and overhead) expenses.					
** Contributions from outside funding sources also anticipated.					

Exhibit F.2

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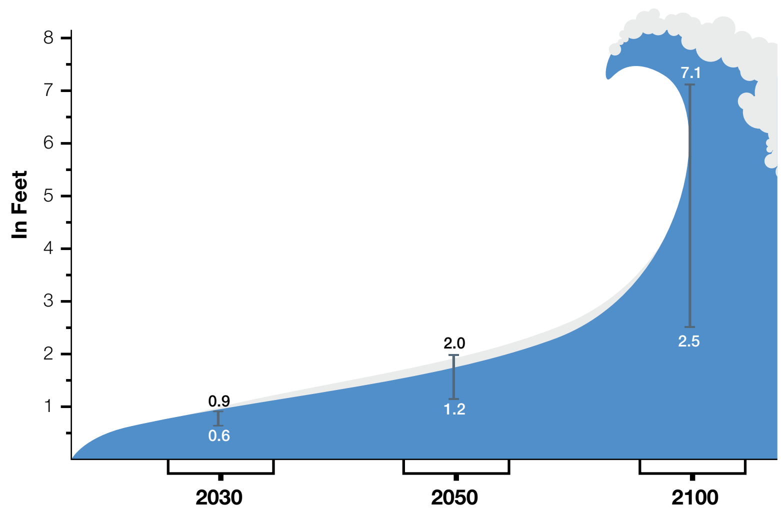
Summary of LAO Report
Preparing for Rising Seas: How the State Can Help Support Local Coastal Adaptation Efforts

Sea-Level Rise (SLR) Impacts Along California's Coast Have the Potential to Be Extensive and Expensive

- California could experience as much as 7 feet of SLR by 2100.
- SLR could have significant impacts on the state's residents, economy, and natural resources.
- Most responsibility for SLR preparation lies with local governments, however the state has a vested interest in ensuring the coast is prepared.
- Waiting too long to initiate adaptation efforts likely will make responding effectively more difficult and costly.

California Sea Levels Are Projected to Rise Significantly



[a] Range of projected SLR scenarios for San Diego from the State of California Sea-Level Rise Guidance Document. Estimates represent the range between "likely" scenarios (66 percent chance of occurring) and scenarios with a 1-in-200 chance of occurring.

LAO

Key Coastal Adaptation Challenges for Local Governments

- Funding constraints hinder both planning and adaptation projects.
- Limited local government capacity restricts their ability to take action.
- Adaptation activities are constrained by a lack of key information.
- Lack of forums for shared planning and decision-making impede cross-jurisdictional collaboration.
- Responding to SLR is not yet a priority for many local residents or elected officials.
- Protracted process for attaining project permits delays adaptation progress.

LAO Recommendations

Foster Regional-Scale Adaptation

- Establish and assist regional climate adaptation collaborative groups to plan together and learn from each other regarding how to respond to the effects of climate change.
- Encourage development of regional coastal adaptation plans to address key vulnerabilities and risks that SLR poses to the region, as well as adaptation strategies the region will take to address them.
- Support implementation of regional adaptation efforts by contributing funding towards construction of projects identified in regional plans.

Support Local Planning and Adaptation Projects

- Increase assistance for cities and counties to conduct vulnerability assessments, adaptation plans, and detailed plans for specific projects.
- Support coastal adaptation projects with widespread benefits such as those that pilot new techniques, protect public resources, reduce damage to critical infrastructure, or address the needs of vulnerable communities.
- Facilitate post-construction monitoring of state-funded demonstration projects to learn more about which adaptation strategies are effective.

Provide Information, Assistance, and Support

- Establish the California Climate Adaptation Center and Regional Support Network to provide technical support and information to local governments on adapting to climate change impacts.
- Develop a standardized methodology and template that local governments can use to conduct economic analyses of SLR risks and adaptation strategies.
- Direct the California Natural Resources Agency to review and report back regarding how regulatory permitting processes for adaptation projects can be made more efficient.

Enhance Public Awareness of SLR Risks and Impacts

- Require coastal flooding disclosures for real estate transactions to spread public awareness about SLR and allow Californians to make informed decisions about the risks of purchasing certain coastal properties.
- Require that state-funded adaptation plans and projects include robust public engagement efforts to help develop societal awareness about SLR, build acceptance for adaptation steps, and ensure the needs of vulnerable communities are addressed.
- Direct state departments to conduct a public awareness campaign about the threats posed by SLR to develop public engagement in and urgency for taking action.

For more information contact: Rachel Ehlers, Rachel.Ehlers@lao.ca.gov, (916) 319-8330

Exhibit F.3

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STORM WATER RESOURCE PLAN

FOR THE GREATER MONTEREY COUNTY INTEGRATED REGIONAL WATER MANAGEMENT REGION

June 27, 2019



Prepared by:
Coastal Conservation and Research, Inc.
on behalf of the
Greater Monterey County Integrated Regional Water Management Region

With Funding Support from:
State Water Resources Control Board
Proposition 1 Storm Water Planning Grant
Grant Agreement No. D1612608

CHAPTER 1. Introduction

This Storm Water Resource Plan has been developed for the Greater Monterey County Integrated Regional Water Management (IRWM) region. The geographic coverage area includes the entirety of the Greater Monterey County IRWM region, plus the portion of the Pajaro River Watershed IRWM region that lies within Monterey County.

The Greater Monterey County IRWM region is characterized largely by intensively farmed agricultural land, rural communities, and a small number of urban areas, the largest of which is the City of Salinas (population approximately 156,000[1]). Groundwater is the primary source of water supply in the region. The Greater Monterey County region receives no imported water, and therefore maintaining the region's water supply is absolutely critical for ensuring the health, prosperity, and long-term sustainability of local communities. The Salinas Valley Groundwater Basin is severely impacted by nitrate contamination, primarily from fertilizer inputs, and by seawater intrusion, due to over pumping. Water quality is a major issue for surface waters as well. The surface waterbodies in the lower Salinas Valley have some of the worst pollutant impairments on the Central Coast, impacted largely by intensive agriculture and nonpoint source pollutants from urban uses.

These water resource issues, along with critical flooding and environmental concerns, have prompted the IRWM Regional Water Management Group (RWMG) and stakeholders in the Greater Monterey County IRWM region to come together for the purposes of storm water resource planning under Proposition 1. The Proposition 1 SWRP planning process has enabled the RWMG and stakeholders to explore new opportunities for storm water and dry weather runoff projects, as well as opportunities for integrating projects, in order to achieve multiple benefits on a regional scale.

This chapter provides the legislative background for developing this Storm Water Resource Plan (SWRP, or Plan), briefly identifies the SWRP planning area, describes the purpose of the Plan along with the approach for Plan development, describes the process for incorporating this Plan into the IRWM Plan and the relationship of this Plan to other SWRPs in the vicinity, addresses certain Standard Provisions of the Storm Water Resource Plan Guidelines including how monitoring will be addressed, and provides a summary of how the Plan is organized.

1.1 Legislative Background and Development of this Plan

Water Code section 10563, subdivision (c)(1), requires a SWRP as a condition of receiving funds for storm water and dry weather runoff capture projects from any bond approved by voters after January 1, 2014.[2] This requirement applies to Proposition 1, the Water Quality, Supply, and Infrastructure Improvement Act of 2014, approved by voters in November 2014. Proposition 1 authorized $200 million in grants for multi-benefit storm water management projects.

[1] 2016 American Community Survey five-year (2012-2016) population estimate.
[2] This requirement does not apply to disadvantaged communities with a population of 20,000 or less, and that is not a co-permittee for an MS4 National Pollutant Discharge Elimination System permit issued to a municipality with a population greater than 20,000 (Water Code section 10563(c) et seq.).

The State Water Resources Control Board (State Water Board) administers the Storm Water Grant Program under Proposition 1. The State Water Board developed Storm Water Resource Plan Guidelines (2015) to assist applicants with the development of their SWRP. A SWRP must comply with the relevant Water Code provisions enacted by Senate Bill 985 in order for individual storm water and dry weather runoff capture projects in the Plan to be eligible for bond funds. This SWRP was developed in accordance with the SWRP Guidelines and complies with all relevant Water Code provisions (see Checklist and Self-Certification in Appendix A).

The SWRP for the Greater Monterey County Integrated Regional Water Management (IRWM) region was developed by Coastal Conservation and Research, Inc., a non-profit organization and fiscal agent for the Central Coast Wetlands Group at Moss Landing Marine Laboratories. The Plan was developed with funding from State Water Board Proposition 1 Storm Water Planning Grant funds (Grant Agreement No. D1612608). Monterey County Resource Management Agency acted as lead public agency for this project.

1.2 Purpose of this Plan and General Approach

The purpose of this SWRP is to promote storm water management implementation projects that provide regionally optimized benefits of increased water supply, improved water quality, better flood protection, enhanced environmental quality, and greater community opportunity. The SWRP achieves that purpose by: characterizing current storm water dynamics in terms of sources, volume, flow, timing, quality, and rights; and identifying geographically and temporally specific opportunities to divert, capture, store, treat, recharge, and reuse this resource to guide the development of implementation projects that optimize regionally integrated benefits.

While traditional approaches to storm water management consider storm water and dry weather runoff as a problem to be addressed, this Plan considers storm water and dry weather runoff as a potential resource. Projects that utilize storm water and dry weather runoff as a resource can result in the following multiple benefits (Water Code sections 10561(g), 10561(h), and 10562(b)(2)):

- creation and restoration of wetlands
- creation and restoration of riverside [riparian] habitats
- maintenance of instream flows
- increases in park and recreation lands
- increases in urban green space
- augmentation of recreation opportunities for communities
- increased tree canopy
- reduced heat island effect
- improved air quality
- improved water quality
- increased water supply
- improved flood management
- increased environmental benefits
- other community benefits

The SWRP uses a watershed-based approach to identify regionally integrated opportunities to beneficially reuse storm water within the Greater Monterey County region. The plan focuses especially on the Salinas, Alisal-Elkhorn Sloughs, and Pajaro watershed areas. Using modeling and other tools, the Plan also identifies priority infiltration and recharge opportunity areas, urban bio-retention areas, and areas for potential floodplain and open space enhancement. Projects in the Plan are prioritized by evaluating project benefits with respect to watershed-based storm water management goals.

This Plan is considered a living document. By identifying both design projects (i.e., defined and ready to go) and concept projects (i.e., opportunities for future project development), the Plan provides a useful and comprehensive long-term planning tool for storm water resource management in the Greater Monterey County region.

Key Definitions (from Storm Water Resource Plan Guidelines):

Storm Water: Temporary surface water runoff and drainage generated by immediately preceding storms.

Rain Water: Precipitation on any public or private parcel that has not entered an offsite storm drain system or channel, a flood control channel, or any other stream channel, and has not previously been placed to a beneficial use.

Dry Weather Runoff: Surface water runoff and flow in storm drains, flood control channels, or other means of runoff conveyance produced by non-storm water resulting from irrigation, residential, commercial, and industrial activities.

Storm Water and Dry Weather Runoff Capture: To intercept, store, manage, and use storm water and dry weather runoff, thereby reducing the volume of runoff exiting a site.

1.3 Incorporation of SWRP into IRWM Plan

1.3.1 Submission of SWRP to IRWM Group

The Greater Monterey County SWRP planning area encompasses the entirety of Greater Monterey County IRWM region, plus the portion of the Pajaro River Watershed IRWM region that lies within Monterey County.

The Greater Monterey County Regional Water Management Group is the entity responsible for decisions related to IRWM planning in the Greater Monterey County IRWM region. The RWMG has served as the Technical Advisory Committee (TAC) for this SWRP, and as such has participated in the decision-making at every major decision point and milestone during the Plan's development. Upon completion of the SWRP, the Plan was formally submitted to the RWMG per the Water Code provisions (section 10562, subd. (b)(7)). On July 17, 2019, at a regularly scheduled RWMG meeting that was open to the public, the RWMG voted to approve the SWRP and to incorporate the SWRP into the Greater Monterey County IRWM Plan. The SWRP is incorporated into the IRWM Plan as Appendix O. Note that since the planning boundaries for this SWRP include a small portion of the Pajaro River Watershed IRWM region, this SWRP will also be presented to the Pajaro River Watershed RWMG for incorporation into their IRWM Plan.

1.3.2 Comparison of Water Resource Management Goals between the SWRP and IRWM Plan

The objectives and projects of the SWRP fit naturally into the broader water management goals of the IRWM Plan. The IRWM Plan is a watershed-based water resource plan that emphasizes integrated projects with multiple water resource and community benefits. The IRWM Plan contains the following seven goals:

- **Water Supply:** Improve water supply reliability and protect groundwater and surface water supplies.
- **Water Quality:** Protect and improve surface, groundwater, estuarine, and coastal water quality, and ensure the provision of high-quality, potable, affordable drinking water for all communities in the region.
- **Flood Protection and Floodplain Management:** Develop, fund, and implement integrated watershed approaches to flood management through collaborative and community supported processes.
- **Environment:** Protect, enhance, and restore the region's ecological resources while respecting the rights of private property owners.
- **Regional Communication and Cooperation:** Promote regional communication, cooperation, and education regarding water resource management.
- **Disadvantaged Communities:** Ensure the provision of high-quality, potable, affordable water and healthy conditions for disadvantaged communities.
- **Climate Change:** Adapt the region's water management approach to deal with impacts of climate change using science-based approaches, and minimize regional causal effects.

The SWRP goals are similar to those of the IRWM Plan, though they focus more specifically on storm water. The SWRP contains the following five goals:

- **Water Supply:** Manage storm water to increase water supply for urban, agricultural, and environmental uses.
- **Water Quality:** Improve water quality so that waters in the planning area are suitable for human and environmental uses.
- **Flood Management:** Manage storm water systems to reduce surface water peak flows and flood risk.
- **Environment:** Protect, preserve, restore and/or enhance watershed features and processes through storm water management.
- **Community:** Enhance economic prosperity and quality of life through improved urban spaces, availability of clean water, and related job creation and training.

Many of the SWRP objectives precisely overlap with those of the IRWM Plan, and all of the SWRP objectives are entirely consistent with the overall intent of the IRWM Plan. (For a more detailed discussion of the SWRP goals and objectives, see Chapter 5, Plan Objectives.) Furthermore, like the IRWM Plan, the SWRP recognizes the added benefit to integration of multiple water management strategies – in this case, storm water management strategies – as compared to stand-alone, single benefit projects. It is therefore natural for the Greater Monterey County SWRP planning effort to have been conducted within the context of the Greater Monterey County IRWM program.

1.3.3 Other Local Plans that may Affect or be Affected by the SWRP

There are numerous plans within the watershed boundaries that directly or indirectly address storm water resource management, including storm water management plans, storm drain master plans, urban water management plans, watershed management plans, general plans, and other local plans. These local plans may affect or be affected by the SWRP in various ways; for example, many of these documents have been used in the development of the SWRP, and the results of modeling and other outcomes of the SWRP may be used to inform future updates of these other plans.

Following is a list of local plans relevant to storm water resource planning and management. See Chapter 4, Organization, Coordination, and Collaboration, for a more complete description of the relationship of the SWRP to these local plans.

- Storm water management plans and guidance documents:
  - City of Salinas Stormwater Management Plan (2013)
  - King City NPDES Phase II Stormwater Management Plan (2009)
  - City of Soledad Stormwater Management Plan (2010)
  - Monterey Regional Stormwater Management Program (2006)
  - City of Marina NPDES Phase II Small MS4 General Permit Guidance Document (June 2013)
  - City of Gonzales NPDES Phase II Small MS4 General Permit Guidance Document (July 2013)

- Storm water and storm drain masterplans:
  - City of Salinas Storm Water Master Plan (2004)
  - Community of Castroville Storm Drain Master Plan (2001)

- Plans that specifically address dry weather runoff:
  - Monterey Bay National Marine Sanctuary: Implementing Solutions to Urban Runoff (1992)

- Plans that specifically address flood management:
  - Monterey County Floodplain Management Plan (2008)
  - Monterey County Multi-Jurisdictional Hazard Mitigation Plan (2014)

- Groundwater management plans:
  - Monterey County Groundwater Management Plan (2006)
  - Salinas Valley Basin Groundwater Sustainability Plan (currently under development)

- Urban water management plans:
  - City of Greenfield (2015, Draft)
  - King City (2015)
  - Marina Coast Water District (2015)
  - California Water Service Company-Salinas District (2015)
  - City of Soledad (2015)

- Watershed management plans that specifically address storm water resource management:
  - San Antonio and Nacimiento Rivers Watershed Management Plan (2008)

- Elkhorn Slough Watershed Conservation Plan (1999)
- Elkhorn Slough at the Crossroads: Natural Resources and Conservation Strategies for the Elkhorn Slough Watershed (2002)
- Moro Cojo Slough Management and Enhancement Plan (1996)
- Northern Salinas Valley Watershed Restoration Plan (1997)
- Reclamation Ditch Watershed Assessment and Management Strategy (2005)

- General plans: All of the general plans in the project area include policies (in public service and/or land use elements) that apply to water conservation, storm drainage facilities, or storm water management. Relevant general plans and community plans include:
  - Monterey County General Plan (2010)
  - City of Marina General Plan (2000, with updates through 2010)
  - City of Gonzales General Plan (2010)
  - City of Greenfield General Plan (2005)
  - City of Salinas General Plan (2002)
  - City of Soledad General Plan (2005)
  - City of Soledad Downtown Specific Plan (2012)
  - King City General Plan (1998)
  - Castroville Community Plan Update 2010

1.4 Consistency with Applicable Laws, Policies, and Permits

The Storm Water Resource Plan Guidelines require that SWRPs address, or provide formal reference addressing, certain "standard provisions," including those listed below. This SWRP and its projects and activities have been vetted to ensure consistency with all applicable laws, policies, permits, and water rights, as follows:

- **California Environmental Quality Act (CEQA):** Implementation of activities and individual projects in the SWRP will not occur unless they are in compliance with CEQA.

- **Water Quality Control Plans:** This SWRP is consistent with, and will assist in compliance with, applicable federal and state regulations and policies, and permits implementing federal and state regulations and policies, including, but not limited to:
  - Clean Water Act and the Safe Drinking Water Act;
  - Water rights permits/licenses;
  - State Water Board plans and policies;
  - State and Regional Water Board water quality control plans and policies, including the Central Coast Basin Plan (2016), Watershed Management Initiative Chapter (2002), and total maximum daily loads adopted by the Central Coast Regional Water Board;
  - Any other federal and/or state laws, regulations, and permits.

- **Other Applicable State Permits:** The SWRP will be implemented in accordance with applicable National Pollutant Discharge Elimination System (NPDES) permits, Waste Discharge Requirements (WDRs), Areas of Special Biological Significance Compliance Plans (State Water Board Resolution 2012-0012), and/or conditional waivers issued by the State and/or Regional Water Boards. Chapter 2 Water Quality Compliance describes how the SWRP is consistent with NPDES permits, WDRs, and conditional waivers issued by the Central Coast Regional Board.

- **California Health and Safety Code – Pest and Mosquito Abatement:** All projects included in this SWRP are subject to the Mosquito Abatement and Vector Control District Law, which requires property owners, including municipalities, to prevent public nuisances caused by property or activity that has been artificially altered from its natural condition so that it does not: support the development, attraction, or harborage of vectors such as mosquitoes and rats; or facilitate the introduction or spread of vectors. Upon its completion, the SWRP will be submitted to local mosquito and vector control districts (including the Northern Salinas Valley Mosquito Abatement District and the Monterey County Department of Health).
- **Modification of a River or Stream Channel:** As required by Clean Water Act sections 401 and 404 and other federal and state laws, regulations, and permits, projects included in this SWRP that include substantial change or use of any material from a river, stream, or lake will be required to avoid and minimize erosion, sediment transport, and hydromodification, and fully mitigate environmental impacts resulting from the projects. These projects may require additional permitting for compliance with Clean Water Act Sections 404 and 401 as well as California Department of Fish and Wildlife regulations.

1.5 Monitoring

To assess the effectiveness of Plan implementation on a watershed basis, SWRPs are required to include a monitoring component to collect statistically meaningful data. This SWRP will support, and will be consistent with, all monitoring requirements associated with applicable Municipal Separate Storm Sewer System (MS4) permits. Each proposed project will be reviewed for the extent to which it collects statistically meaningful data and follows monitoring requirements associated with applicable MS4 permit(s).

For individual projects within a watershed that may impact or have a potential to impact water quality, proposed monitoring will be evaluated to ensure integration of existing local, regional, or statewide monitoring efforts. All projects must adhere to certain State guidelines for monitoring. These include:

- Projects that involve surface water quality must meet the criteria for and be compatible with the Surface Water Ambient Monitoring Program (SWAMP): http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml).
- All projects that involve groundwater quality must meet the criteria for and be compatible with Groundwater Ambient Monitoring and Assessment (GAMA): http://www.waterboards.ca.gov/gama/).
- All projects that involve wetland restoration must meet the criteria for and be compatible with the State Wetland and Riparian Area Monitoring Plan (WRAMP): http://www.waterboards.ca.gov/mywaterquality/monitoring_council/wetland_workgroup/docs/2010/tenetsprogram.pdf

All monitoring data will be stored in centralized local, regional, or statewide water quality data collection systems, including the State Water Board's California Environmental Data Exchange Network (CEDEN), SWAMP, and GAMA. See Chapter 8, Information and Data Management, for further discussion on monitoring and data management.

1.6 Organization of this Plan

This SWRP adheres to the State's Storm Water Resource Plan Guidelines, and is organized as follows:

- **Chapter 1. Introduction**: Describes the purpose of the Plan, development of the Plan, and addresses Standard Provisions.
- **Chapter 2. Water Quality Compliance**: Identifies water quality issues within the major watersheds, and includes discussion of the SWRP in relation to applicable TMDL Implementation Plans and MS4 Permits.
- **Chapter 3. Watershed Identification**: Identifies the SWRP boundary and watersheds within the planning area.
- **Chapter 4. Organization, Coordination, and Collaboration**: Describes the RWMG, discusses public engagement efforts, and describes coordination with agencies and organizations with regard to storm water and dry weather runoff management.
- **Chapter 5. Storm Water Management Objectives**: Identifies the storm water goals and objectives of this Plan.
- **Chapter 6. Quantitative Methods for Identification and Prioritization of Storm Water and Dry Weather Runoff Capture Projects**: Describes the narrative and quantitative goals for the five multiple benefits in each of the four main sub-watersheds in the planning area, and the methods used to derive them.
- **Chapter 7. Evaluation and Prioritization of Projects**: Includes a prioritized project list, and describes the quantitative analyses employed to identify opportunities and the use of that information to identify, evaluate, and prioritize the storm water management projects.
- **Chapter 8. Information and Data Management**: Describes the data management system including types of data gathered, data formats for transfer to regional and statewide systems, data storage and retrieval, back-up systems, and security.
- **Chapter 9. Implementation Strategy and Schedule**: Describes an overall coordinated strategy to facilitate the successful implementation of projects listed in this Plan.
- **Chapter 10. Education, Outreach, and Public Participation**: Describes the community engagement process that occurred during Plan development.
- **Chapter 11. References**

Disclosure Statement:

Funding has been provided in full or in part through an agreement with the State Water Resources Control Board using funds from Proposition 1. The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Exhibit F.4

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Salinas River State Beach
Dune Restoration and Management Plan

Central Coast Wetlands Group and Coastal Conservation and Research
in partnership with California State Parks

Funding provided by the California State Coastal Conservancy

January 2016

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CONTENTS

Existing Conditions and Background

Introduction

The following Restoration and Management Plan has been prepared by the Central Coast Wetlands Group (CCWG) and Coastal Conservation and Research (CCR) in partnership with the California State Parks (DPR) as part of the Salinas River State Beach Dune Restoration project being funded by the Coastal Conservancy through the Climate Ready Grant Program. This document will help guide the restoration and monitoring of sand dune habitat at selected sites at Salinas River State Beach in Moss Landing, California. No development or construction is planned as part of this project, only the fencing of walking paths and installation of educational signage.

Site Description

Salinas River State Beach (SRSB) comprises approximately 280 acres of beach and coastal dunes located in Northern Monterey County, California (Figure 1). SRSB is bordered by the Pacific Ocean to the west and the old Salinas River channel and agricultural fields to the east. SRSB extends northward to Sandholdt Road in Moss Landing and southward to the Salinas River mouth, wrapping around the Monterey Dunes colony in the lower half of the state beach. The most prominent feature of the state beach is the extensive sand dune system, which extends inland in some places for over 1000 feet and is 50–60 feet above sea level at the highest point.

The SRSB was classified as a state beach by the California State Park and Recreation Commission in November 1962, to "protect and perpetuate the area's natural resource values and to provide beach-oriented recreation opportunities for the enlightenment, inspiration, and enjoyment of present and future generations (DPR 1987). The State Park and Recreation Commission resolution establishing the state beach specifically distinguishes the foredune and coastal scrub plant communities, the solitary sandy beach, the visual texture of the dunes and the expanse of Monterey Bay as the important elements. SRSB is also zoned as "scenic and natural resource recreation" in the North County Land Use Plan and "recreational" within the Monterey Bay National Marine Sanctuary.

The entirety of the SRSB lies within the California Coastal Zone, consequently potential human-caused alteration (e.g., development) or impacts to "environmentally sensitive habitats (ESHAs)" are subject to review under the California Coastal Act, Article 5, Section 30240(a). The provisions of the Coastal Act are administered locally by the California Coastal Commission in cooperation with Monterey County. Chapter 3 of the Coastal Element describes the specific development activities that are permitted within ESHAs, including coastal dunes and wetlands (CCC 1976).

SRSB contains rare coastal dune and coastal marsh habitat which provide habitat for many species of wildlife and migratory birds, and which host numerous special status animal and plant communities. SRSB also contains two subunits classified as Natural Preserves: the Salinas River Dunes Natural Preserve and the Salinas River Mouth Natural Preserve. The qualities that make this area a haven for wildlife and a hotspot for rare plant communities also attract visitors who seek open space, solitude and a natural landscape relatively untouched by development. Beach combing, bird watching, photography, jogging, horseback riding and surfing are popular recreational uses of the state beach, but it is not uncommon for visitors to have the beach or the dunes to themselves, especially in winter.

There are three public parking and access locations associated with the SRSB. One is located at the Sandholdt Road access at the north boundary of SRSB. It is paved and has space for approximately 40 vehicles. The Potrero Road parking lot is located on county property, is unpaved, and has space for approximately 60 vehicles. Similarly, the Molera Road parking lot is paved and has space for approximately 50 vehicles. There are no facilities associated with the state beach. The Potrero Road parking lot provides pedestrian and equestrian access to the beach and is owned by the county. The Molera Rd parking lot offers pedestrian and equestrian access to the beach and is owned by DPR. Parking at Sandholdt Road is pedestrian access only and is also owned by DPR. SRSB is owned and operated by DPR.

With only these three entry points for this 3.6 mi (5.6 km) long area of the state beach, much of the use occurs near these locations. Whether visitors enter at Sandholdt or Potrero or Molera Road, the beach is the destination area for most visitors in the state beach. Between Sandholdt and Potrero Roads, visitors can follow a trail that runs behind the dunes along the Old Salinas River channel. In the dunes around and between the two northern access points, many volunteer trails run from the ridge trail through the dunes to the beach. The ridge trail spans the northern half of the state park and terminates at the Molera Road access point. Equestrians are directed to ride on the horse trail or on the beach on the wet sand to protect sensitive plant and animal species. Due to the dynamic nature of the shore environment, conditions along the beach and dunes are constantly changing.

PLANTS AND ANIMALS AT THE DUNES

Plant and animal species that inhabit the dunes are specially adapted to the dynamic system of moving sand and wind. Plants that grow within the permeable, blowing substrate are either short-lived or persist through the development of deep, extensive root systems. Vegetation patterns within the dunes are strongly correlated with dune morphology (Pickart 1998). Seedling establishment is variable depending upon the species and micro-environments to which the seeds are carried. Animals that inhabit coastal dune habitats are subject to physical stresses that include sand movement, salt spray, temperature variability, wind, and disturbances such as storms. Their adaptations are mostly behavioral. Species such as western snowy plover shelter in depressions in the sand in the coastal strand where they also forage and breed. Invertebrate species such as globose dune beetle complete their entire life cycle in the dune habitat. Open areas or low vegetation in dune areas can support ground-nesting species such as California quail. SRSB supports populations of federally and state listed and special status animal species (8), plant species (4) and plant communities (2) and several species endemic to California.

Plants

There are three plant communities at SRSB: foredune, coastal scrub and dune pond. The most common plant species of the foredune are sand verbena (*Abronia umbellata* and *A. latifolia*), beach bur (*Ambrosia chamissonis*), beach sagewort (*Artemsia pycnocephala*), beach saltbush (*Atriplex leucophylla*), and beach pea (*Lathyrus littoralis*), all native species, and sea rocket (*Cakile maritima*), sea and Hottentot fig (*Carpobrotus chilensis* and *C. edulis*) and European dune grass (*Ammophila arenaria*), all non-native invasive species. The coastal scrub community occupies a narrow strip between the foredune and the old Salinas River channel. The most common species are mock heather (*Ericameria ericoides*), coast buckwheat (*Eriogonum latifolium*), Lizard Tail (*Eriophyllum staechadifolium*), bluff lettuce (*Dudleya farinosa*) and sea fig (*Carpobrotus edulis*). The dune pond in the southern end of SRSB was created by the shifting mouth of the Salinas River. The pond is seasonal and is surrounded by a sparse cover of sedges, rushes and grasses.

Several special status plants and plant communities occur within SRSB (Table 3, Figure 3), including Menzies' wallflower (*Erysimum menziessi*i ssp. *menziesii*), Monterey gilia (*Gilia tenuiflora* ssp. *arenaria*), Monterey spineflower (*Chorizanthe pungens* var. *pungens*), and sand-loving wallflower (*Erysimum ammophilum*), as well as central dune scrub and northern coastal salt marsh communities.

Although there is a wide diversity of native species present in the SRSB, recent analysis of aerial imagery revealed that iceplant cover ranges from 35 to 65% with an average of 48% across the foredune community. Non-native invasive iceplant spreads through seed production and vegetative propagation, tolerates a range of soil moisture and nutrient conditions and can establish and grow in the presence of herbivores and competitors. These qualities enable iceplant to out-compete many native species and dominate resources, including space. In areas where iceplant has died and regrown, the build-up of organic matter can enable invasion by other non-native plants that would not ordinarily establish in the normally sandy soils.

Animals

There are many invertebrate and vertebrate species found at SRSB. The beach and littoral zone are used by resting, feeding and nesting gulls and shorebirds. Observations include Caspian and elegant terns (*Hydroprogne caspia*, *Thalasseus elegans*, and *T. maximus*, respectively), many species of shorebirds, gulls, and waterfowl, such as sanderlings (*Calidris alba*) and willets (*Tringa semipalmata*), Heermann's, California and Western gulls (*Larus heermanni*, *L. californicus*, and *L. occidentalis*, respectively), many of which may feed on small crustaceans, molluscs and worms in the sandy intertidal. Vegetation in the foredune and coastal dune scrub communities provide food, cover, and nesting sites for many species of insects, birds, amphibians, reptiles and mammals. Velvet ants, ground-nesting wasps and bees, scarab and dune beetles and many other insects live in the dunes. Harriers and songbirds may forage on the plants and animals found in the dune scrub plant community. Amphibians and reptiles include the Pacific tree frog (*Pseudacris regilla*), Coast garter snake (*Thamnophis elegans terrestris*), and the northern alligator lizard (*Elgaria coerulea*). Mammals such as coyotes (*Canis latrans*), raccoons (*Procyon lotor*), feral cats (*Felis catus*) and non-native red foxes (*Vulpes vulpes*) may hunt birds and smaller mammals in the dune habitat.

Several special status animals occur within SRSB (Table 3, Figure 4 & Figure 5) and include globose dune beetle *(Coelus globosus)*, California legless lizard *(Anniella pulchra)*, tidewater goby *(Eucyclogobius newberryi)*, longfin smelt *(Spirinchus thaleichthys)*, bank swallow (*Riparia riparia*), western snowy plover *(Charadrius nivosus nivosus*), and short-eared owl (*Asio flammeus)*.

DUNES AND ICEPLANT

The five kilometer sand dune complex spanning the central Monterey Bay from the Moss Landing harbor mouth southward to the Salinas River Mouth is part of an ancient dune system that formed and stabilized during the Wisconsin glaciation (Dorrell-Canepa 2005). Dunes within the central Monterey Bay accrete sand through a complex interaction of littoral transport south from the Santa Cruz littoral cell to the mouth of the Monterey Bay Submarine Canyon at Moss Landing and local deposition of fresh sands from the Salinas River immediately south of the canyon. Strong seasonal winds and changing wave patterns drive beach sands inland forming an extensive dune complex.

Historically, the Salinas River flowed west to the coast where its flow was directed north along the eastern side of the dunes northward. The river bisected the dunes at numerous locations between its current location and a location north of Elkhorn slough where the Salinas met the mouth of the Pajaro River. In 1910 the Salinas River mouth was relocated at its current condition directly west of the point where the river once transitioned north behind the dunes. Between the 1854s and 1910 the mouth was located north of the current Moss Landing Harbor mouth in what is now Bennett Slough (Figure 6). In 1946 the Moss Landing Harbor Mouth was constructed, permanently bisecting the Salinas dunes complex.

Invasive Iceplant Impacts on Central Coast Dunes

As development pressure expanded in the early 20th century, within and adjacent to the central Monterey dune system, there was a perceived need to stabilize the dunes and limit natural dune migration and sand movement. Initially, iceplant was populated along the coastal railroad corridor and later the species was actively planted by the military and state agencies (Cal Trans) to stabilize dune systems and protect adjacent properties from drifting sand (Au 2000).

The California Invasive Plant Council (Cal-IPC) classifies the impact of iceplant (*Carpobrotus edulis*) on native ecosystems as *high*. Species with a *high* rating have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure and their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment (Cal-IPC 2006). *C. edulis* effectively eliminates other species within areas it colonizes through several competitive advantages, leading to monotypic stands of this single species. *C. edulis* can reproduce through seeds dispersed by animals and through fragmentation and regrowth. Iceplant establishes a dense cover of plant material that eliminates open dune space and impedes recruitment of native species, especially species that require periodic disturbance for recruitment (D'Antonio and Mahall 1991).

Loss of Native Species Diversity

The central Monterey Bay dunes system once reported supporting more than 50 species of plants. Today, at least 30 species can still be found within the Salinas State Beach dune system but the abundance of many of these species has been reduced significantly.

As noted above, numerous special status species occur in the central Monterey Bay sand dune system. Species of particular interest for this restoration project as Salinas State Beach include the Monterey spineflower (*Chorizanthe pungens*) and Sand gilia (*Gilia tenuiflora*). Both species benefit from natural dune systems devoid of iceplant that exhibit periodic disturbance and open sand areas. The removal of dense iceplant will allow for greater open area for the recruitment of native species including spineflower and gilia.

Iceplant Cover and Distribution

Iceplant has recruited and now dominates most of the SRSB dune complex. Initial aerial estimates of iceplant percent cover in project locations were completed to develop work plan costs (Table 1). The remainder of the dune plant community is comprised of a mix of native species including those within Table 2.

PREVIOUS RESTORATION EFFORTS IN MONTEREY BAY

This project creates a necessary connection between two ongoing related projects, the Moss Landing State Beach Coastal Dune Revegetation Plan to the north and the Monterey Dunes Colony restoration closer to the southern boundary of SRSB, and a historical project, the restoration of sand dunes at Moss Landing Marine Laboratories.

Moss Landing State Beach (MLSB) Restoration Activity

MLSB consists of 66 acres of coastal sand dune, beach and salt marsh habitat and is located immediately north of the Moss Landing harbor inlet. Haphazard beach access has caused a loss of dune vegetation, resulting in blowout areas and sand moving into the state beach access roadway. DPR and the Elkhorn Slough Foundation have partnered to conduct dune restoration at MLSB, including eradication of non-native species, replanting of native dune plants, and maintaining beach access points to clearly delineate walking paths and prevent trampling of sensitive dune habitat. This work began in late 2013.

Monterey Dunes Colony Restoration Activity

Monterey Dunes Colony is a 120 vacation home community on 125 acres of sand dunes that is bordered on the north, south, and west by the SRSB. The Monterey Dunes Colony recently initiated a small demonstration project in which they brought in sand and recontoured foredunes to 3–4 ft. above grade and then planted the new dunes with local native seeds and seedlings. The total project area was approximately 1000 square feet. The project was conducted to demonstrate to DPR and the California Coastal

Commission that importing sand could be done without negatively impacting DPR land or western snowy plovers. This work began in January 2015.

Moss Landing Marine Laboratories (MLML) Restoration Activities

The beachside Moss Landing Marine Laboratories campus was destroyed in the 1989 Loma Prieta earthquake. Part of the rebuilding effort of MLML included sand dune reconstruction and restoration on a 2-acre parcel where most of the buildings and structures of the labs had been prior to their destruction. The site was heavily disturbed due to trampling from people crossing the dunes to get to the beach from the parking lot. Reconstruction and restoration included recontouring the sand dunes, removal of iceplant, propagation and planting of native dune plants, and placement of signage and fencing to protect the vulnerable site. Work began in 1992 and was largely finished by 1999.

Dunes as Coastal Protection from Storms

Threats to Salinas Valley from Sea Level Rise

Several recent studies regarding coastal vulnerabilities to Sea Level Rise (SLR) have documented the adaptive capacity natural ecosystems can provide to protect coastal areas from those vulnerabilities. Langridge et al. 2013 documents the future vulnerability of the Salinas Valley to rising seas and models the protective capacity that natural sand dunes can play to protect the valley from storm induced flooding. This project will document the importance dune restoration can have to improve the resiliency of dunes to storm damage.

Specifically, native dunes plants develop deep root systems that provide erosive resilience and support natural sand migration and accumulation patterns that are expected to dissipate wave energy without leading to significant dune face failure. The foredune plants form low sloping dune faces that encourage wave run-up energy to dissipate rather than undercut foredunes dominated by Iceplant. Studies suggest that the removal of iceplant and reestablishment of native species will enable dune complexes to better respond to wave impacts, which will enable them to be more resilient to more frequent and more damaging storms (De Lillis et al. 2004).

Dune Protection

The sand dune complex that parallels the central Monterey Bay between the current location of the Salinas River mouth and Moss Landing Harbor has been in place since the opening of the Harbor and the breaching of the River at its current location. The dunes provide a natural buffer from ocean derived processes (waves, sand deposition, salt spray) and the productive agriculture fields of the Salinas Valley. The historical Salinas River (now Old Salinas River channel) flows behind the dunes between the river and Moss Landing Harbor. Water elevation within the channel is regulated by the Old Salinas River slide gates at the river lagoon and the Potrero tide gates which limits tidal exchange with the harbor.

The Salinas Valley is most vulnerable to coastal flooding from storm induced wave run-up and dune overtopping at three locations between the Salinas River (with its levee protections) and the Potrero tide gates to the north. These locations all are dominated by invasive iceplant and are the most narrow sections of the dune system. These dunes are backed by agriculture fields, which limits future dune migration. Sand supply along this portion of the coast, adjacent to the Salinas River mouth is assumed plentiful and can support dune building processes.

Recent SLR hazard maps, created by the State Coastal Conservancy and ESA PWA (2014) for the Monterey Bay Coast, identify two sections of the SRSB as being highly vulnerable to storm induced dune and beach erosion and flooding, which will be exacerbated by SLR. A study conducted by the Center for Ocean Solutions in 2012 shows this area to be at the greatest risk of future dune erosion due to SLR. SRSB provides a natural ocean barrier to thousands of acres of low lying agricultural and wetlands resources that are protected from winter storms by these dunes (Langridge 2014). Sand dunes, in their natural state, dissipate wave run-up erosive energy and minimizing ocean induced dune undercutting and inland flooding, while providing critical habitat to many special status species.

The natural dune vegetation at SRSB, however, has been disrupted by the introduction of iceplant (*Carpobrotus edulis*) and other invasive plants. Iceplant is an invasive species that has choked local dune systems and impacted important physical and ecological dune functions. The documented degradation of foredune habitat by invasive species undermines the dune's capacity to act as a protective barrier to SLR. Restoring impacted dune areas identified as being most vulnerable to SLR restore a unique and sensitive habitat of the Salinas Beach Natural Preserve and river mouth lagoon, but will also enhance the resiliency of the dune system from the multiple impacts of SLR.

Small breaches in the two most vulnerable sections of the SRSB could allow ocean flooding of vast areas of the Salinas Valley. **This project seeks to reduce climate related vulnerabilities of two potential breach points in the Salinas River State Beach dunes complex by improving the natural adaptive capacity of these coastal dunes.**

Restoration Plan

Summary

CCWG and CCR will work in partnership with DPR to restore (eradicate invasive iceplant and reestablish native plants) invasive iceplant from approximately 20 acres of sensitive dune habitat in areas that have been identified as being vulnerable to sea level rise impacts. Iceplant will be eradicated primarily through the use of hand spraying herbicide (2% dilution of Roundup). Hand pulling of iceplant will be used in areas where special status plant species are present. Sprayed iceplant will be left in place to act as mulch for native plants. Iceplant will be left to decompose for approximately 4–9 months before native plants are planted within it. Seeds from native plants for propagation and hand broadcasting will be collected from the SRSB dunes complex to ensure local genetic diversity is supported. Approximately 20,000 native plants will be propagated throughout the project period and planted during the 2016/2017 and 2017/2018 planting season. Additionally, seeds will be hand broadcast and lightly raked in to dune areas with bare sand. Efforts to increase the structural integrity of the dunes will include strategic planting placement and the use of drift wood or jute fencing to help build dunes. Several trail upgrades will be made that include updating or replacing fencing to help better delineate access ways and reduce wayward foot traffic through sensitive dune habitat. Interpretive signs will be installed at two main access locations and along main dune trails to provide education about sea level rise, dune erosion, habitat restoration, and endangered species.

Restoration Goals and Objectives

Goal 1: Eradicate iceplant from fore and mid dunes
Goal 2: Establish diverse native plant species composition in treated dune areas
Goal 3: Enhance storm resilience of dune system and report results
Goal 4: Support DPR efforts to enhance long-term management of Monterey dune ecosystems

Goal 1. Eradicate Iceplant from Fore and Mid Dunes

Iceplant Eradication

A field crew of 2–4 members will be responsible for spraying iceplant within the 20-acre target fore and mid dune area (Figure 2) in the early spring and fall and early winter of 2016. Spraying will occur approximately 4–9 months prior to revegetation efforts to allow enough time for the iceplant to decompose and allow for easier planting. Areas with thick iceplant may need to wait until after the second year of spaying before planting. In areas with a substantial cover of native species, iceplant should be sprayed in late fall 2016 when the natives are essentially dormant and germinating native seedlings are limited. In weedy, disturbed areas, iceplant can be sprayed in early to late spring 2016 and 2017 so that the annual weeds are also eliminated before their seed is dispersed.

Crew members will be trained to properly identify iceplant and native dune species (including *Dudleya*) and will have proper certifications to use the spray application equipment. A 2% dilution of Roundup (2% glyphosate/1.5% imazapyr mix + surfactant solution) with added tracer die will be used. Iceplant will be sprayed in linear swaths parallel to the shore by the field crew in a manner that limits dune trampling. Spraying will be limited to still and dry days to prevent chemical drift from rain and wind. A second spot application will be completed approximately 3–9 months after the initial application to address areas where iceplant remains robust. The foredune areas will be sprayed outside of the Snowy Plover nesting season (March–September) to ensure breeding plovers are not impacted. Mid and backdune areas may be sprayed or hand weeded year round if approved by DPR and Point Blue partners. Sprayed iceplant will be left in place to act as mulch for new native plants.

In many places, native species are intermixed with the iceplant and therefor care will be taken to minimize drift or overspray of herbicides on native plants. No spraying will occur in areas where sand gilia and Monterey spineflower are present. Iceplant in those areas will be hand pulled to protect the special status plants. After planting and seeding occur, herbicide spraying will be limited to areas where overspray will not jeopardize native plants.

Small patches of iceplant may be hand pulled whenever staff familiar with the eradication procedures is on site. Iceplant will be disposed of offsite in approved composting areas.

Additional Invasive Species Control (as funding permits)

1. **Iceplant outside of the project focus area:** Successful eradication and/or control of iceplant populations require management of recruitment of new plants from adjacent areas. Iceplant fragmentation and seed dispersal from adjacent dunes can lead to re-establishment of populations within the restored areas. Annual spot check surveys and removal of recruits is necessary. Fragmentation and encroachment by existing iceplant populations within adjacent areas of the dunes represents a significant challenge to maintenance of restored areas. As funding allows, the restoration team will work with DPR to spray and manually remove iceplant inland of the restoration focus area to ensure that recruitment pressure to the foredune after restoration is managed. Project staff will identify priority areas within the back dune community where iceplant can be eliminated, establishing isolation areas to protect the restoration program and support long term elimination of iceplant from the dune system between the Salinas River and the harbor mouth, to provide maximum adaptive capacity to SLR.

2. **Spraying of European beach grass (*Ammophila arenaria*):** Ammophila sp. Is present on the adjacent Monterey Dunes Colony property and has recruited to one area south of the Colony. Herbicide application staff will treat the area with 2% glyphosate/1.5% imazapyr mix + surfactant solution during at least two application periods. Additional spot checks will determine the effectiveness and additional treatment requirements. Native dune grasses will be planted in place of the European populations after spraying ends.

3. ***Arundo donax* management**: *Arundo donax* is present near the southern end of the focus area and efforts will be made to eliminate the species from the north River mouth area. The *Arundo* will be cut

by mechanical means and the cut stump will be treated with a 50–100% solution of Roundup. Additional spot check applications will be made during the second year.

Long-term Weed Eradication and Control

Spot check surveys of the restored dune areas by will occur each year to document native plant growth and succession patterns and to identify areas where iceplant recolonizes. Recolonized areas will be noted using a GPS unit and reported to the Project Manager and DPR staff. As resources are available, qualified field crews will revisit areas where iceplant reestablishes and spray or pull the plant as needed. Work will be scheduled to avoid impacts to western snowy plovers

Goal 2. Establish Diverse Native Plant Composition in SRSB Dunes

Species Composition of Dune Complex

The most dominant plant species of the Salinas River State Beach dunes include those listed in Table 2 and will be planted in densities sufficient to achieve a percent of plant cover similar to reference areas.

Seed Collection

Trained botanists and restoration crew members will collect seeds of native species listed in Table 2 at the Salinas River State Beach dunes complex to ensure local genetic diversity is supported. Seed will be collected under the supervision of a restoration biologist by permission from DPR. Maximum genetic diversity shall be assured by collecting seed from un-restored sections of the nearby dunes, and by gathering from as many different plants of the same species as possible. No more than 10% of the produced seed from any one plant shall be collected. Seeds will be collected in the fall and stored until early spring when the seeds will be broadcast within the dune focus areas or planted in the greenhouse for propagation and future out planting. Seed will be collected each year for propagation and out planting during the fall/winter planting season.

Dune Grass Rhizome Collection

Native dune grass planting is most successful using small plugs generated from segmenting adult plants. Local dune grasses will be collected in small numbers and planted in a greenhouse to generate an adult population from which to establish rhizome plugs for out planting.

Broadcast Seeding

A seed mix of native species will be created (based on Table 2) and field crew will hand broadcast the seeds in areas where the sand is relatively stable and some native vegetation is present. Broadcast seeding is an effective way to help reclaim pathways and bare areas on the foredune. Further broadcast seeding may be feasible where spayed iceplant has been decomposing for over one year. Broadcast seeding will be done prior to the first rains (Nov–Jan). Seed may also be broadcast and raked into barren back dune areas if seed supply is available and if seeding the area is not expected to negatively impact snowy plover breeding habitat per DPR and Point Blue guidance. Seed will be spread by hand onto the sand or fully decomposed iceplant litter and raked in lightly. Two seed mixes shall be created, corresponding to the species diversity of the fore or mid-to-rear dunes. An estimate of 10 pounds per acre of seed is needed where broadcast seeding will occur.

Dune Plant Propagation

Species from the DPR approved list will be collected within (1km) of the project site. Quantities of individual plants of each species will be grown and out planted in numbers to reestablish the expected diversity and density. The use of perlite soil amendment for seed propagation will help reduce soil compaction, low water retention and high permeability found within the soil type of coastal dunes. Depending on the species, propagation will begin between winter and spring to allow for seedlings to grow large enough to be out planted in late fall (Nov/Dec) prior to first rains. Consistent watering, thinning to one seedling per cell, and the prevention of herbivory are all essential for the survival and health of the dune seedlings.

1. **From seed**
   Seeds will be propagated in 3” deep trays with a mixture of perlite and top soil or potting soil. Once seedlings have germinated they will be transplanted into 2” pots within a soil/sand mix and grown out.

2. **From plant material (rhizomes)**
   Leymus mollis will be propagated/divided from parent material/cuttings taken from approved locations within the project site. Cuttings will be planted in 2” pots. Recommended spacing between plants is 18” and 36” between strip rows.

Native Species Out-planting Techniques:

1. **Iceplant mulch and native planting**
   Desiccated iceplant material will be present throughout the dunes after the herbicide spraying (approximately 6 months after initial application). This mulch material provides enhanced conditions for survival of planted juvenile native species. The mulch layer provides insulation from extreme soil temperature fluctuations, retains dune moisture, inhibits weed colonization and can enhance fog condensation (D’Antonio 1990, Magnoli 2013). A four-inch spade will be used to cut through the iceplant mulch and juvenile native plants will be planted. Sand and mulch will be laid around the plant and water will be applied. Plants will be placed at distances of 6 to 18 inches apart, dependent on the expected width of a one-year-old plant. Several studies have found that iceplant removal areas (with and without the presence of iceplant mulch) can enhance invasive, non-native annual grass recruitment (Magnoli 2013). Invasive annual grasses are not a problem within the Salinas River State Beach and therefore not a significant concern. Surveys will be completed to ensure that invasive grasses do not become a problem.

2. **Planting on bare sand**
   Some native plants will be planted in foredune areas where no plants currently exist. In these areas, plants will be planted within small mounds (3” high) above the base elevation to reduce

burial. Plants will be watered after planting. Plant spacing in this area will be determined in close consultation with DPR and Point Blue to ensure that snowy plover breeding habitat is not negatively impacted.

3. **Planting in straw bales**
   Straw bales may be placed in low density in areas where excessive human trampling has led to a degradation of dune contours. Straw bales will be placed at low density to encourage rebuilding of foredune habitat that replicates natural topographic variability. Native foredune plants (i.e. *Leymus*) will be planted within and adjacent to the bales to stabilize the structures and increase foredune roughness and stability.

4. **Watering**
   All greenhouse reared plants will be out-planted in the late fall, scheduled to coincide with first rains. Additional watering during the project period may occur if necessary.

GOAL 3. ENHANCE STORM RESILIENCE OF DUNE SYSTEM

Increasing Erosive Resistance of Dunes

Several studies have documented the increased vulnerabilities to wave impacts posed by iceplant invasion on native dune systems. Sand dune vegetation plays a primary role in dune stabilization (De Lillis,2004), and the loss of plant species that trap sand make the beach more vulnerable to wind and wave derived erosion. In areas open to direct winter wave action, waves can impact the steep edges of iceplant hardened fore-dunes causing undercutting beneath the plant biomass, washing away underlying sands below the shallow root zone, leading to catastrophic failure. In contrast, native dune species of the central Monterey Bay establish deep root matrixes that provide a three dimensional lattice of roots and mycorrhizae that resists wave and wind erosion and support vertical plant growth in step with dune formation (Dorrell-Canepa 2005).

The restoration of coastal dune systems can retard coastal erosion. Removal of the exotic ice plant (*C. edulis*) can lead to an increase in native dune species and to the re-establishment of a more dynamic foredune community. Such restoration has been recommended as an initial response to projected dune erosion from sea level rise and helps to maintain natural coastlines and dune systems at far less expense than coastal armoring (De Lillis et al. 2004, Langridge et al. 2014)

Several studies suggest that restoring the complexity of dune species (De Lillis et al. 2004) and the reestablishment of native foredunes can aid the long term resiliency of dunes to wave derived erosion. This structural complexity is anticipated to play a key role in maintaining resilience as ocean levels rise and dunes are required to adapt and migrate. This project anticipates and will study how the removal of *C. edulis* and the replanting of native foredunes species enhance foredune stability and resilience due to storm induced wave impacts; that will intensify as ocean levels rise.

Key Processes of Foredune Failure

Three key processes that lead to foredune failure will be ameliorated through removal of iceplant and reintroduction of native species.

1. **Catastrophic dune edge collapse**
   Foredunes dominated by ice plant capture and retain sand while forming a dense canopy and a steep dune face. While these dune edges (usually located above high water line) may be resistant to average wave patterns, wave impacts during large storm events can hit the dune edge with significant force, washing sand from below the ice plant canopy, resulting in mass wasting events and the loss of all plant material on the face of the fore dune.

2. **Increase in wave run up energy**
   Foredunes edges dominated by ice plant often are devoid of plant material between the foredune edge and the water. The steeper ice plant dominated foredune fails to reduce wave runup energy as is common from gradually sloped foredune with sparse native plants that provide foredune roughness and protection provided by the deep root systems of the native plants. Restoration of sparse and diverse foredune species will reduce wave runup energy through increased roughness and a more gradual foredune slope.

3. **Reduced vigor of native species**
   Several studies have documented the impacts on native dune plants in the vicinity of iceplant due to subsurface competitive interactions that lead to stunted growth of native plants (D'Antonio et al. 1991). Both above and below ground biomass of native species is reduced leading to less efficient accumulation of sand and reduced subsurface root biomass and dune structure (D'Antonio et al. 1991, Jucker 2013).

Key Actions to Reduce Erosion

Key actions that will be taken to reduce these three coastal erosion processes include:

1. **Increase complexity of foredune**
   Native species will be planted within areas where ice plant was removed. Species including the native dune grass (*Leymus mollis*) and beach bur (*Ambrosia chamissonias*) will be planted directly in front of dunes with steep faces.

2. **Enhance structural integrity (using driftwood) of foredune**
   Locally derived large driftwood will be placed in areas along the foredune where dunes are steep and where previous wave erosion scars are evident. The wood will be placed in low density to increase roughness and provide three-dimensional stability as native species reestablish. *

3. **Enhance contours to reduce erosive impacts of waves**
   There are several areas of the Salinas River State Beach where dune erosion is evident and may lead to further wave impacts and possible dune overtopping during extreme storm events.

a. **Eliminate perpendicular access ways:** There are several coastal access ways from inland trails and parking lots that lead out to the beach perpendicular to the shore. These visitor derived dune scars provide optimal wave ramps and funnels to encourage wave run-up and potential dune overtopping. By realigning these access ways (through restoration and fencing of a portion of the broad beach entrance) to angle away from the dominant wave angle, these enhanced access ways will limit wave funneling.

b. **Encourage dune aggradation and enhanced dune roughness in low relief foredune areas:** Several strategies will be used to aid sand accumulation in areas where sand migration and foredune topography have been compromised by ice plant.

   i. Native plantings of beach bur and dune grass will be placed forward of the dune faces to encourage low density reestablishment of native species and foredune topographic complexity*.

   ii. Straw bale planting mounds will be placed in low density in areas where erosion scars have cut into the foredune to eliminate wave run-up ramps*.

   iii. Decomposing drift fence (jute and bamboo) may be used in short segments (as not become a barrier to plover movement) to encourage sand deposition, reestablishing foredune complexity*.

   iv. Opportunistic sand placement will continue to be discussed with Monterey County to investigate future use of sand removed to breach the Salinas River lagoon. No sand placement is planned for this project.

   v. Locally derived driftwood may be placed sparsely along the dune front to increase foredune roughness and complexity*. Driftwood will not be used as an alternative to coastal hardening.

*Note: All area-specific planting and the use and placement of drift wood or straw bales will be reviewed and approved by DPR and Point Blue in advance of plantings.

GOAL 4. SUPPORT CALIFORNIA STATE PARKS DUNE MANAGEMENT EFFORTS

Trail System Upgrades

SRSB has approximately 7,000 feet of existing trails in the dune system. With direction from DPR, the project will install or upgrade post and cable, no-climb fencing, or a similar type of fencing at access points and priority trails in order to protect sensitive habitat, reduce erosion caused by wayward foot and vehicle traffic, and to delineate public access corridors to the beach. DPR has prioritized fencing needs at the Molera Road and Sandholdt Road access points where wayward trails are most abundant (Figure 7). Specific locations to install new or upgrade existing fencing include the western edge of the Sandholt Road parking lot/entrance (530 feet) and along both sides of the trail from the Molera parking lot to the beach (1600 feet). If the budget allows, additional locations for fence installation or upgrades will be determined by DPR.

Additional trail upgrade work may include the removal of the dilapidated boardwalk at Molera Road beach access, as it presents a liability hazard for public use at SRSB. The debris would be removed to a certified recycling or landfill facility.

Interpretive Signage

To enhance visitor appreciation, enjoyment, and knowledge of SRSB, interpretive signs will be constructed at coastal access points and along main dune trails to provide education about sea level rise, dune erosion, habitat restoration, and endangered species (Figure 7). One 3-paneled kiosk will be installed at the Molera Road beach access parking lot, two 2'x3'low profile interpretive signs will be installed at the Potrero Road beach access parking lot, and approximately ten "kindly keep off the dunes" regulatory/interpretive signs will be installed along beach access trails and along the dune/horse trail. Please see Figure 8 for design of low-profile and kiosk interpretive signs. If budget permits, additional signs may be placed at the neighboring Monterey Dunes Colony to help inform this community about the sensitive dune habitat and sea level rise. All interpretive sign design and language will be approved by DPR to ensure that signs meet DPR standards. Interpretive signs will be made of a material that resists damage by vandals and the weather. Low profile signs and kiosks will be secured into the ground by concrete footings. No signs will be installed on the beach. Additional temporary signs prohibiting entry into restoration may read "Restoration in progress- Please Do Not Enter" and will be placed at the edges of the restoration areas.

Expansion of Iceplant Eradication Efforts

CCWG and CCR will work with DPR and grant funding programs to identify additional resources to expand and maintain the iceplant eradication and native species planting efforts. Long term management of the SRSB will require adequate funding and time to ensure all iceplant is removed and that DPR has the resources to quickly address recolonization of iceplant.

Dune Restoration Monitoring

Periodic plant monitoring efforts will be completed to quantify native species abundance and diversity, track changes in dune topography and identify and address recolonization by iceplant. Surveys will be completed by trained researchers and scheduled in foredune areas and other breeding habitat outside of the snowy plover nesting season. Please see the Plant Surveys section of this document for more information.

Avoidance and Mitigation Measures

All sensitive species and their habitats were evaluated for potential impacts by this project (CCWG 2015, Appendix B). Any potential impacts to native animal species are likely to be minimal and temporary, while the benefits are expected to endure. Project guidelines have been developed and will be implemented to avoid, reduce, or mitigate impacts (to a less than significant level) to the native fauna including the sensitive and special status species.

The sparsely vegetated dunes, beach and river mouth area of SRSB provide important breeding habitat for the western snowy plover. The snowy plover breeding season occurs from March 1 to September 30 each year. No project activities will be scheduled within the breeding habitat during the breeding season. Some project activity may be conducted in the mid to rear dune coastal scrub during the plover breeding season, but only at the discretion of DPR biologists in consultation with Point Blue ecologists.

Because this project proposes to install native vegetation in sparsely vegetated areas, it will be important not to decrease the amount or quality of breeding habitat available for western snowy plovers at SRSB. Area-specific planting plans and the use of straw bales will be reviewed and approved by DPR and Point Blue biologists in advance of plantings. Plans will be modified if they appear to negatively alter plover habitat. Additionally, plants may be removed if important breeding areas are inadvertently planted too densely.

For a complete list of avoidance and mitigation measures and project requirements please see Appendix B.

Restoration Schedule

	2016				2017				2018
	winter	spring	summer	fall	winter	spring	summer	fall	winter
Restoration									
Iceplant Eradication: Spray and hand									
Plant Propagation									
Outplanting									
Seed Collection for Broadcast									
Broadcast Seeding									
Trail Enhancement									
Sign Design and Construction									
Trail Fencing									
Monitoring									
Vegetation Monitoring									
Dune Morphology Monitoring									
Dune Restoration Best Practices Study									

MONITORING PROGRAM

SUMMARY

Periodic plant and dune monitoring efforts will be completed to quantify native species abundance and diversity, track changes in dune topography and identify and address recolonization by iceplant. Surveys will be completed by trained researchers and scheduled in foredune areas outside of Snowy Plover nesting season.

PLANT SURVEYS

Methods

Plant surveys will be conducted throughout the project period. Vegetation surveys will document successful reestablishment of native plant species, successful eradication of invasive plants and identify areas where greater species diversity is needed. Additional surveys will occur at Moss Landing State Beach where a restoration project is already in place to help compare restoration success. Presence of iceplant during monitoring will be noted and reported to maintenance crew for spraying or hand removal. Vegetation monitoring will occur once before project initiation, twice a year during implementation, and once post implementation. Ongoing vegetation surveys past the project period will be conducted by CSUMB restoration ecology students. Vegetation monitoring will consist of three separate approaches (Figure 9):

1. **Point-intercept transects perpendicular to the coastline (percent cover)**
   Transects will be aligned with dune topography study benchmarks, and in between the benchmarks as needed. Each 50 m transect will be laid perpendicular to shore and plant species will be recorded every half meter. The datasheet will be set up so that spatial information will be recorded. The zero mark will be on the ocean side of the dune and will increase moving inland. The transition from foredune to mid-dune will be recorded for each transect. In this way each transect can be separated into foredune and mid/upper dune, and the overall cover of plant species, bare sand and litter can be estimated for these zones.

2. **Parallel transects (percent cover and species richness).**
   Transects will be laid parallel to the coast within restoration areas. One randomly placed quadrat ($1m^2$) will be sampled within every 100-meter segment along transects. Percent cover will be estimated within each quadrat. Further, rare species along the entire transect will be noted. These transects will quantify the diversity on the site to capture the presence of rare species.

3. **Treatments in replicates.**
   A study will be set up to help investigate best practices for eradicating iceplant and establishing natives on dunes. During initial monitoring, five large contiguous areas of iceplant (over 30 square meters) will be flagged to become replicate study plots. Within each plot, several restoration

treatments will be determined based on priority research questions. Each treatment will be replicated across each of the five study plots. Treatments may include clearing space around planting vs. planting directly into decomposed iceplant, driwater vs. no supplemental water, and planting at different densities of plant species. The individual treatments will be implemented within 2m diameter circular plots, which will be delineated using a central point and a 2m string or tape. These points will be marked with flags and the GPS location recorded. Percent cover and survivorship of plantings will be recorded during each sampling event.

Sampling Schedule

Sampling events will occur twice a year during the project period (2016–2018), and then once a year post-implementation dependent by CSUMB students. Surveys will occur outside of the plover season, so the fall data collection will be after September 30th and the spring data collection will be before March 1st.

Topographic Surveys

Methods

Dune profile surveys will be conducted before and after project implementation using differential GPS equipment. LiDAR data will also be collected to document beach and dune profiles. Future surveys will document topographic profiles and dune elevation changes expected within naturally evolving dune complexes.

A beach/dune morphology baseline of the study area will be created before project implementation. DEMs of the entire section of the beach between the mouth of the Salinas River and the head of the Monterey Canyon and adjacent dunes will be created based on the stereophotogrammetric analysis (~2cm resolution) of surveys recently conducted (October 2015) with an Unmanned Aerial Vehicle (UAV).

Terrestrial Laser Scanner (TLS)-based, beach/dune morphology baselines to measure beach/volume change will be produced using a Trimble VX Spatial Station. This state-of-the-art spatial station is equipped with Direct Reflex (DR) technology, a direct drive system with robotic servo-mechanisms and a built-in digital camera. The instrument is operated via radio-link by a controller unit, it can acquire accurate (<3 mm), multiple (15 points/s) spatial data (point clouds), and the range of operation of the DR laser is 2- to 500 m while on target mode (optical prism mounted on a survey rod) the acquisition can work as far as 2 km.

The TLS surveys will occur along 8 transects (spaced about every 500m). The survey areas will cover a coast-parallel band of approximately 200m centered at the survey benchmark. For each survey area 2 stable benchmarks (physically a ~5 foot long rebar hammered in the ground) will be determined using a differential GPS (horizontal and vertical accuracy ~2cm). The point cloud produced will include a cross-shore transect from the dune crest(s) to the beach. Scanning resolutions will range between 10 and 50cm with approximately 10,000 points collected per survey (Datums WGS84, NADV88). DR-technology and single point measurements with a survey rod will be combined to account for geomorphological features (e.g. slope of the foredune) not directly visible from the TLS or for areas covered by intense vegetation.

Post-processing of the TLS data will be done with Real Works (software by Trimble). Post-processing operations include editing of the point clouds, merging of point clouds and survey points collected from different fore-sights, interpolation and contouring, creation of surface meshes, and photographic rendering of three-dimensional (3D) surface models. Real Works will also be used for the analysis/parameterization of the surface scans (e.g. volumes, slope angles), to compare TLS and UAV data and for the serial scans to identify and quantify areas subjected to volume changes. The vertical datums of the beach and dunes will be defined relative to the operational MHW elevation datum for the Monterey Bay area (MHW for the closest tidal station Monterey Harbor is 1.40m NADV88).

Sampling Schedule

Sampling events will occur once a year during implementation (2016–2018) and will coincide with vegetation surveys. Post-implementation surveys will be conducted once a year dependent on additional funding. Surveys will occur outside of the plover season, so the fall data collection will be after September 30th and the spring data collection will be before March 1st.

Exhibit F.5

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AB 691 Sea-Level Rise Assessment

Moss Landing Harbor

Sea Level Rise Vulnerability and Adaptation Strategy Report

June 2019

Prepared for the Moss Landing Harbor District

Prepared by the Central Coast Wetlands Group

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Table of Contents

1. Introduction

Report Goals

This project will achieve four objectives (as defined by the State Lands Commission) intended to further regional planning for the inevitable impacts associated with predicted Sea Level Rise (SLR) on the Moss Landing Harbor, Elkhorn Slough and adjacent beach areas within the properties in and adjacent to the state lands granted to the Moss Landing Harbor District. Goals include:

- Identify what critical coastal infrastructure would be compromised due to predicted SLR for time horizons 2030, 2060[1], and 2100 and for extreme SLR scenarios (H++).
- Identify what critical coastal subtidal habitats would be compromised due to predicted SLR for time horizons 2030, 2060, and 2100 and for extreme SLR scenarios (H++).
- Identify appropriate response strategies for these risks and discuss the programmatic and policy options that can be adopted to address these risks.
- Quantify the potential financial losses of infrastructure within the predicted hazard zones and the costs of adaptation alternatives.

Products of this report include:

1. An assessment of the impact of SLR on granted public trust lands, as described in the Resolution of the California Ocean Protection Council on Sea-level Rise and the latest version of the State of California Sea-Level Rise Guidance Document.
2. Maps showing the areas that may be affected by SLR in the years 2030, 2060, and 2100. These maps shall include the potential impacts of 100-year storm events. A local trustee may rely on appropriate maps generated by other entities.
3. An estimate of the financial cost of the impact of SLR on granted public trust lands. The estimate considers, but is not limited to, the potential cost of repair of damage to, and the value of, lost use of improvements and land, and the anticipated cost to prevent or mitigate potential damage.
4. A description of how the local trustee proposes to protect and preserve natural and manmade resources and facilities located, or proposed to be located, on trust lands and operated in connection with the use of the trust lands. The description shall include, but is not limited to, how wetlands restoration and habitat preservation might mitigate impacts of SLR.

[1] In 2014 local SLR models were developed for the Monterey Bay and 2060 hazard predictions were selected instead of 2050 values. This decision has been determined by the State to meet state planning guidelines.

Background Vulnerability Assessments

In 2013 the State of California adopted policy requiring all entities with granted public trust lands to draft sea level rise vulnerability plans for resources within the jurisdictional boundaries of their State lands.

In 2017, the Central Coast Wetlands Group at Moss Landing Marine Labs (CCWG) completed a community-wide sea level rise vulnerability analysis for the Moss Landing Community.[2] The resulting report was funded by The Ocean Protection Council through the Local Coastal Program Sea Level Rise Adaptation Grant Program. This grant program is focused on providing resources to local governments to support the update to Local Coastal Programs (LCPs), and other plans authorized under the Coastal Act[3] such as Port Master Plans, Long Range Development Plans and Public Works Plans (other Coastal Act authorized plans) to address sea-level rise and climate change impacts, recognizing them as fundamental planning documents for the California coast.

The County of Monterey developed and adopted a Local Hazard Mitigation Plan in 2014. This plan works to “identify and profile natural hazards [storm surge, coastal erosion, earthquake, expansive soils, flood, and tsunami] and to lesser extent manmade hazards; assess vulnerability; set local hazard mitigation goals and strategies; and plan for future maintenance of the Local Hazard Mitigation Plan.”[4] Sea level rise is not explicitly addressed by the plan, though increased intensity of coastal erosion and storm flooding due to sea level rise are discussed. The plan explores integrated mitigation strategies, which include actions to reduce vulnerability from erosion, flooding, and other natural and human hazards.

The Moss Landing Community Plan[5] discusses sea level rise and the importance of armoring the coastline in order to protect the harbor and its related coastal uses. This vulnerability report is intended to aid future planning to increase resiliency and provide greater detail on the risks to the Moss Landing area from coastal climate change during three future time horizons (2030, 2060 and 2100). Risks to properties were identified using the ESA PWA Monterey Bay Sea Level Rise Vulnerability Study[6] layers developed in 2014 using funding from the California Coastal Conservancy.

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[2] Moss Landing Coastal Climate Change Vulnerability Report (2016)

[3] State of California. *California Coastal Act of 1976*. http://www.coastal.ca.gov/coastact.pdf

[4] Monterey Multi-Jurisdictional Hazard Mitigation Plan, 2014, ch 2, pg 3

[5] Moss Landing Community Plan, Revised Draft 2014

[6] ESA PWA. 2014. *Monterey Bay Sea Level Rise Vulnerability Study: Technical Methods Report Monterey Bay Sea Level Rise Vulnerability Study*. Prepared for The Monterey Bay Sanctuary Foundation, ESA PWA project number D211906.00, June 16, 2014

2. Sea-level Rise Vulnerability Assessment

Inventory of Vulnerable Natural and Built Resources and Facilities

State Grant Tide and Submerged Lands Description

In 1947 the State of California granted the Moss Landing Harbor District the Submerged and Tide lands of the Old Salinas River channel below the Potrero and Moss Landing tide gates and includes the main channel of Elkhorn and Bennet sloughs and the coastal tide lands to the north and south of the Moss Landing Harbor entrance (Figure 1). Within this area are significant natural habitat features, historical infrastructure (in various stages of disrepair) and currently operating infrastructure managed by the Harbor District, the Moss Landing power plant, the County, and by adjacent private land owners. Portions of the submerged lands of Elkhorn Slough are designated as Marine Protected Areas and managed by the Department of Fish and Wildlife and the Elkhorn Slough National Estuary Research Reserve.

The Moss Landing Harbor is the number one commercial fishing harbor in the Monterey Bay with 600+ slips for recreational boaters and commercial vessels. Partnering with marine research and education institutions, the Moss Landing Harbor District (MLHD) provides full public access to the marine environment. Designated as a year-round port of safe refuge, Moss Landing Harbor provides safe, reliable marine refuge and services to members of the boating public. Moss Landing Harbor supports the research and educational endeavors of the Monterey Bay Aquarium Research Institute and Moss Landing Marine Laboratories.

More than 100 active fishing vessels can be berthed in Moss Landing at any time along with 7 research and government vessels. Two eco-tour pontoon boats are docked here as well as charter fishing boats, whale watching vessels, and numerous kayak rentals and ecotourism businesses. The harbor supports commercial fishing and recreational boating as well as restaurants. The Jetty Road sand spit is located along the northeast side of the harbor. The Moss Landing Harbor provides parking and other harbor and beach access facilities which are located within both the north and south harbor areas (north and south of the main harbor entrance).

Moss Landing Harbor properties are surrounded by water—the ocean, Elkhorn Slough, Moro Cojo Slough, and the nearby Salinas River. The proximity to the Monterey Bay National Marine Sanctuary and the open ocean makes Moss Landing Harbor a valuable maritime resource that is also vulnerable to periodic impacts from ocean storms that will be exacerbated by sea level rise. Storm events have impacted the community in the past; including the 1995 flood and the 1982 and 1998 El Nino events. Each of these climatic events has damage infrastructure and properties.

This map was prepared by the staff of the California State Lands Commission. The map was based upon information available to the staff at the time of the survey. It does not reflect legislation, court decisions, or other information unavailable to staff at the time of the survey. Therefore, while useful for general grant administration purposes, the true boundaries may not be those depicted.

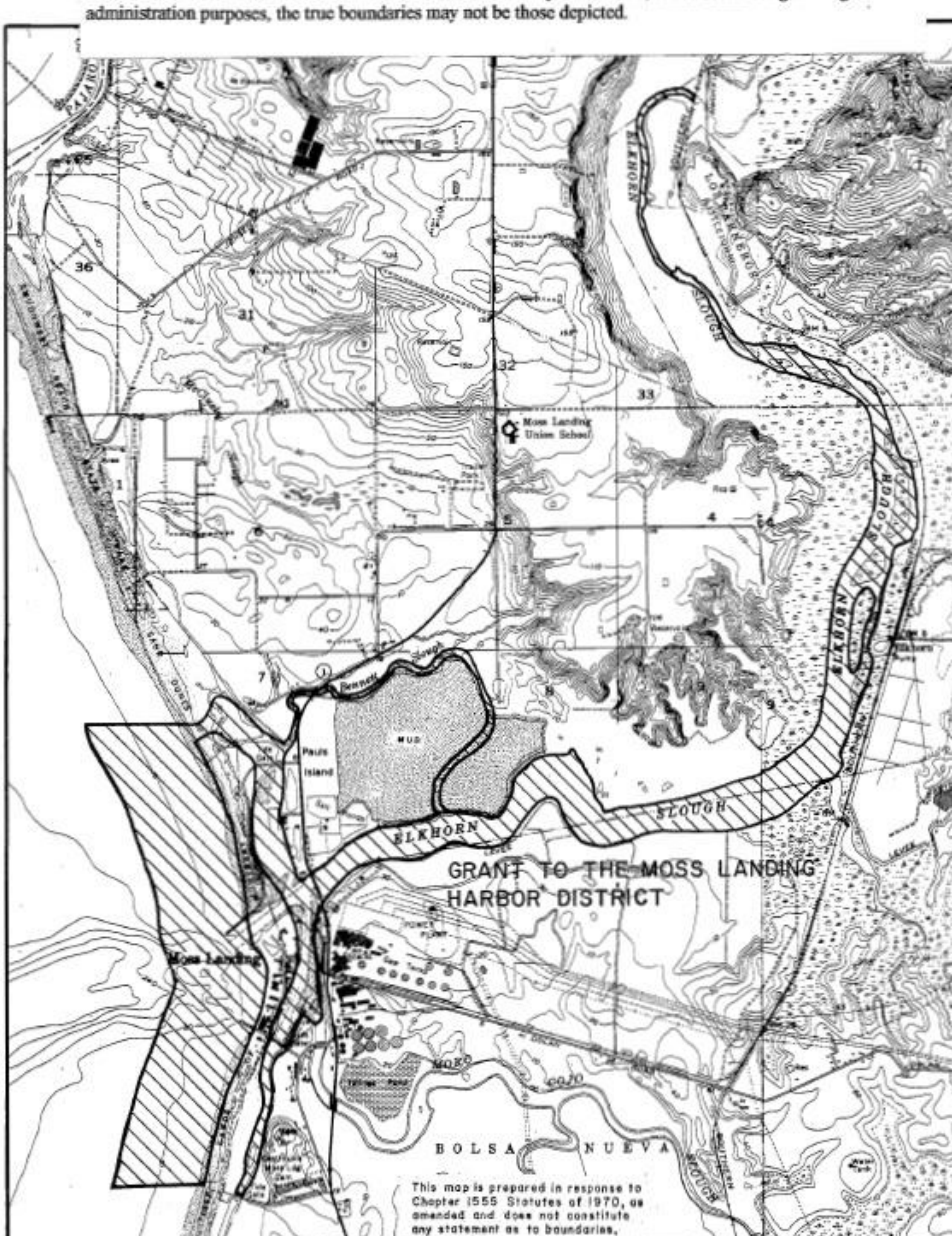

Figure 1. Submerged lands granted to Moss Landing Harbor District

Harbor Shoreline Structures

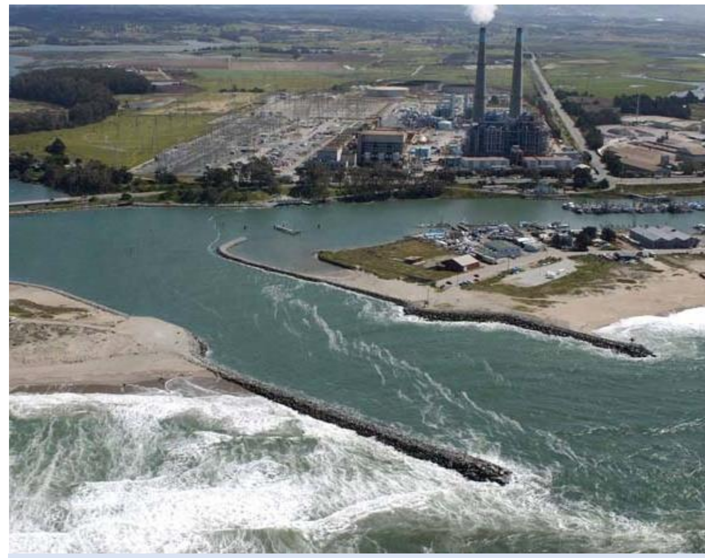

Figure 2. Moss Landing Harbor levees

(Image: Copyright 2002-2017 Kenneth & Gabrielle Adelman, California Coastal Records Project, www.Californiacoastline.org)

Much of the Moss Landing Harbor is developed for commercial and recreational boating with shoreline edges comprised of a mix of rip-rap and concrete sea walls. A large amount of harbor related infrastructure was built within the footprint of the historical Old Salinas River. The Harbor entrance is maintained by two large rock jetties that reach more than 1,500 feet out from the main harbor channel into the open Monterey Bay (Figure 2). The harbor mouth and main harbor channel are dredged periodically to maintain operational depth. While the jetties remain in good condition, the sand behind the inland end of structures has eroded by tidal eddies that scour sand and deposit those sediments elsewhere (in the north harbor area). Most of the 2.5 km of the south harbor waterfront is man-made and or hardened with rip-rap or concrete. Only one quarter (0.5km) of the north harbor waterfront is protected or hardened.

Tidal Management Structures

A number of tide gates, culverts and other water control structures have been installed, replaced, and upgraded since the late 1800s. Many of the structures were installed when the harbor was created to reduce erosion, lessen inland saltwater migration, and control tidal action. Many of these structures are in disrepair and maintenance responsibilities are not well defined and distributed among a number of state and county agencies. The Harbor District staff notes that the loss of wetlands in portions of Elkhorn Slough and the Bennett Slough have been intensified by the breaching (in the 1980s) of the original protective levees (which were installed when the harbor mouth was opened) in the eastern areas of the Elkhorn Slough, and the opening of the Bennett Slough to tidal scour when Jetty Road was rebuilt after the 1989 earthquake.

Moss Landing Village

The community of Moss Landing is a small fishing village with restaurants, antique stores, and galleries, best known for its working harbor and proximity to Elkhorn Slough and the productive fisheries of the Monterey Bay.

Elkhorn Yacht Club

Elkhorn Yacht Club was founded in 1946. The Elkhorn Yacht Club Mission Statement is: “A safe, family friendly, thriving entity providing our members with a social environment focused on ocean sports, environmental footprints and lifelong friendships.” The club supports expansive facilities overlooking the channel leading to the Elkhorn Slough. It hosts a bar, waterfront patio with fire rings, a garden courtyard, hearth room, dining hall, and kitchen.

Recreation and Public Access

Beaches, Parks, and Reserves: Moss Landing State Beach, Salinas River State Beach (part of which is designated as the Salinas River Dunes Natural Preserve), and Zmudowski State Beach Park, located to the north and south of the harbor entrance, offer great places for surfing, horseback riding, surf fishing, windsurfing, hiking, and wildlife-watching.

The Elkhorn Slough National Estuarine Research Reserve, the Elkhorn Slough State Marine Reserve, and the Moss Landing State Wildlife Area (limited recreation access), encapsulate Elkhorn Slough and its many surrounding wetlands, while also providing more than five miles of hiking and boardwalk trails, and a visitor center with restrooms and a paved overlook road. The slough is also accessible by kayak or small boat from the harbor, allowing up-close viewing of the incredible biodiversity.

The Monterey Bay Marine Sanctuary Scenic Trail runs through Moss Landing, helping link the Santa Cruz and Monterey County coastal access infrastructure.

Coastal Access and Public Parking: Boats within the harbor offer tours of Elkhorn Slough and the Monterey Bay National Marine Sanctuary to observe local wildlife. There are public parking lots and street parking on Jetty Road, just off of Highway 1, to provide easy access to the beach. There is a parking lot at Elkhorn Yacht Club, and there are parking lots around the harbor providing access to the Slough and the ocean. Access and parking to Salinas River State Beach is provided at the ends of Sandholdt, Potrero and Molera roads.

Transportation

Highway 1: Highway 1 runs through Moss Landing with a bridge crossing Elkhorn Slough. There are three locations along the highway where motorists can exit the highway and access the Harbor.

Rail: The rail line transects the Moss Landing area passing through Elkhorn and Moro Cojo sloughs. The rail line is operated by Southern Pacific for both commercial and passenger service.

Bridges: There are a number of bridges and roads that overpass the complex network of creek and wetland features within Moss Landing.

Moss Landing and Sandholdt Roads: Moss Landing and Sandholdt roads provide access to much of the Harbor Districts infrastructure and maritime access.

Natural Resources

Wetlands: Elkhorn Slough’s tidal salt marsh provides critical habitats for many species, including more than 135 species of aquatic birds, 550 species of marine invertebrates, and 102 fish species, as well as sea otters, sea lions, and harbor seals. Surrounding wetlands including the Moro Cojo Slough and Old Salinas River provide important habitats for threatened species and flood attenuation during winter storms.

Dunes*:* The beach dunes along Moss Landing State Beach and Salinas River State Beach provide important habitat for many native plants and animals, including the western snowy plover, the white-tailed kite, western fence lizard, beach wild rye, beach bur, yellow sand verbena, and many more species.

Protected Habitats: Monterey Bay National Marine Sanctuary, Elkhorn Slough State Marine Conservation Area, Elkhorn Slough State Marine Reserve, Elkhorn Slough National Estuarine Research Reserve, Moss Landing State Wildlife Area, Moro Cojo State Marine Reserve, Salinas River Dunes Natural Preserve, and California State Beaches support special status species and their habitats.

Assets Used in Study

To meet AB 691 guidelines, this vulnerability assessment evaluates: 1) harbor infrastructure within the harbor public trust lands that are vulnerable to SLR and Climate Change impacts, 2) natural resources within areas vulnerable to SLR directly associated with harbor operations, 3) protective infrastructure (and associated development on those properties) that provide a buffer/boundary from ocean impacts, 4) Public access points and county roads needed to provide access to harbor infrastructure and properties, and 5) infrastructure and properties that are outside the public trust boundaries that are vulnerable to projected hazards and are vital to the continued operations of the harbor (Table 1).

Table 1. List of Assets Used in Analysis

ASSET CATEGORY	ASSET
Harbor Infrastructure	Harbor buildings
	Docks and entranceways to docks
	Electric meters
	Storm drains
	Trash enclosures
	Lift stations
	Parks
	Bathrooms
Access	Roads and parking
	Coastal access points
Natural Resources	Wetlands (NWI)
	Eelgrass beds
	Marine mammal haul-out areas
	Beaches and dunes
Protective Infrastructure	Coastal armoring
	Harbor jetties
	Culverts and tide gates
Infrastructure Outside of State Granted Lands	Buildings and parking lots

Current State Sea Level Rise Policy Guidance

Coastal Hazard Models

State guidance suggests that "a Bayesian probabilistic framework can support improved decision making and easily integrate new lines of scientific evidence but may under- or overestimate sea-level rise contributions beyond 2050 and could lead to confusion if decision makers are unclear about the difference between Bayesian and frequentist probabilities. Nonetheless, probabilistic projections represent consensus on the best available science for sea-level rise projections through 2150. With continued advances in sea-level rise science, it is expected that probabilistic projections will change in the future. However, the evolving nature of sea level rise projections does not merit taking a 'wait and see' approach. Acting now is critical to safeguard the people and resources of California."

However, within the Monterey Bay, probabilistic models are not yet available. Therefore, this study uses scenario-based models developed in 2014 which follow previous State guidance and crosswalks them with the most recent guidance. Previous guidance from The California Coastal Commission guidance document[7] recommends communities evaluate the impacts from sea level rise on various land use categories using a method called "scenario-based analysis" (described in Chapter 3 of the Guidance). Since sea level rise projections are not exact, but rather presented in ranges, scenario-based planning includes examining the consequences of multiple rates of sea level rise, plus extreme water levels from storms and El Niño events. As recommended in the guidance, this report uses sea level rise projections outlined in the 2012 NRC Report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*[8] (Figure 3).

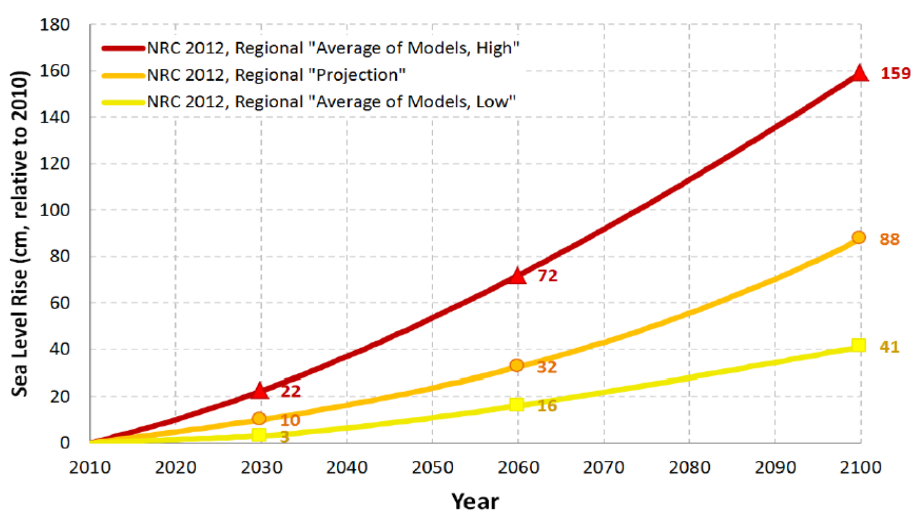

Figure 3. Sea level rise scenarios for each time horizon (Source: ESA 2014)

[7] California Coastal Commission. 2015. *California Coastal Commission Sea Level Rise Policy Guidance: Interpretative Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits.* Adopted August 12, 2015.

[8] National Research Council (NRC). 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. Report by the Committee on Sea Level Rise in California, Oregon, and Washington. National Academies Press, Washington, DC. 250 pp.

The goal of scenario-based analysis for sea level rise is to understand where and at what point sea level rise and the combination of sea level rise and storms, pose risks to coastal resources or threaten the health and safety of developed and natural areas. This approach allows planners to understand the full range of possible impacts that can be reasonably expected based on the best available science, and build an understanding of the overall risk posed by potential future sea level rise.

The guidance recommended evaluating the impacts of the highest water level conditions that are projected to occur in the planning area. In addition to evaluating the worst-case scenario, planners need to understand the minimum amount of sea level rise that may cause impacts for their community, and how these impacts may change over time, with different amounts of sea level rise.

The climate vulnerability maps used for this study identify hazard zones for each climate scenario for each of the three planning horizons. For clarity, this report focuses the hazard analysis on a subset of those scenarios, that can be cross-walked with the probabilistic based-scenario (Table 2).

Table 2. Comparison of OPC 2013 Guidance Document and 2018 Update's Probabilistic SLR projections

SCENARIO BASED PROJECTION: TIME HORIZON	SCENARIO BASED PROJECTION: EMISSIONS SCENARIO	SCENARIO BASED PROJECTION: SLR[9]	PROBABILISTIC PROJECTION: EMISSIONS SCENARIO	PROBABILISTIC PROJECTION: LIKELY RANGE*: 66% PROBABILITY SLR IS BETWEEN…	PROBABILISTIC PROJECTION: 1-IN-200 CHANCE**: 0.5% PROBABILITY SLR MEETS OR EXCEEDS…	H++ SCENARIO***
2030	Med	4 in	High	**3.6 – 6 in**	9.6 in	12 in
2060	High	28 in	Low	6 – 14.4 in	**27.6 in**	45.6
			High	8.4 – 16.8 in	31.2 in	
2100	High	63 in	Low	10.8 – 27.6 in	**66 in**	121.2
			High	18 – 39.6 in	82.8 in	

*Notes: * low risk aversion projection, **Medium-high risk aversion projection, ***Extreme risk aversion projection*

For management of ongoing harbor operations, considerations regarding predicted time horizons should be taken when decisions as to if and how to adapt are made. Specifically, new infrastructure built within hazard zones should be designed to withstand the predicted hazards while accommodating the appropriate level of uncertainty regarding the scale of the hazard (i.e. water elevation) and the predicted time horizon when these hazards will occur (i.e. 2030 through 2060). Red text highlights corresponding probabilistic sea level rise predictions with those used for modeling of Moss Landing Harbor hazards (scenario-based model). Because such probabilistic projections have not yet been integrated with predictions for storm intensity and wave height and for changes in rainfall, and future

[9] Erosion projections: 2030: Includes long-term erosion and the potential erosion of a large storm event (e.g. 100-year storm), 2060 and 2100: Includes long-term erosion and the potential erosion of a large storm event (e.g. 100-year storm). Future erosion scenario: Increased storminess (doubling of El Niño storm impacts in a decade).

emissions scenarios are extremely uncertain, it is likely inaccurate to assume the predicted impacts have less than a 1% chance of occurrence by 2060.

Impacts of Storms and Extreme Events

This sea level rise vulnerability analysis uses hazard layers developed by ESA in 2014 and modified by CCWG in 2016 to account for currently existing coastal armoring and other protective structures. The ESA coastal hazard modeling and mapping effort[10] led to a set of maps that integrate the multiple coastal hazards projected for the assessment area (i.e. hazards of coastal climate change). There is however a benefit to evaluating each hazard (or coastal process) separately. The hazard layers are available for further investigation through the online mapping viewer at www.coastalresilience.org.

Two important limitations of the original hazard maps were addressed within this focus effort for Moss Landing. ESA was contracted for this project to model the impacts of flooding from the combined effects of rising seas and changes in rainfall leading to an increase in winter stream flows. CCWG staff post-processed the 2030 hazard layers to account for reductions in potential hazards provided by current coastal protection infrastructure (tide gates, etc.). This refinement of coastal hazard mapping helped to better understand the future risks Moss Landing may face for each coastal hazard process.

It is understood that each modeled coastal process will impact various coastal resources and structures differently. This report evaluates the risks to infrastructure from each coastal hazard for each time horizon. This analysis helps to link risks with appropriate adaptation alternatives. The following is a description of the hazard zones that were used for this analysis. For more information on the coastal processes and the methodology used to create the hazard zones please see the Monterey Bay SLR Vulnerability Assessment Technical Methods Report.[10]

Combined Hazards

CCWG merged the coastal hazard layers (for the specific scenarios[11] as modified to account for structures) to create a new combined hazard layer for each planning horizon (2030, 2060 and 2100). These merged layers represent the combined vulnerability zone for "Coastal Climate Change" for each time horizon. Projections of the combined hazards of Coastal Climate Change are intended to help estimate the cumulative effects on the community and help identify areas where revised building guidelines or other adaptation strategies may be appropriate. Combined hazards however, do not provide municipal staff with the necessary information to select specific structural adaptation responses. Therefore, this study also evaluates the risks associated with each individual coastal hazard.

Rising Tides

These hazard zones show the area and depth of inundation caused simply by rising tide and ground water levels (not considering storms, erosion, or river discharge). The water level mapped in these inundation areas is the Extreme Monthly High Water (EMHW) level, which is the high water level reached approximately once a month. There are two types of inundation areas: (1) areas that are clearly connected over the existing digital elevation through low topography, (2) and other low-lying areas that

[10] ESA PWA. 2014. *Monterey Bay Sea Level Rise Vulnerability Assessment Technical Methods Report*

[11] See the 2017 Santa Cruz County Coastal Climate Change Vulnerability Report for the discussion on scenario selection

don't have an apparent connection, as indicated by the digital elevation model, but are low-lying and flood prone from groundwater levels and any connections (culverts, storm drains and underpasses) that are not captured by the digital elevation model. This difference is captured in the "Connection" attribute (either "connected to ocean over topography" or "connectivity uncertain") in each Rising Tides dataset. These zones do not, however, consider coastal erosion or wave overtopping, which may change the extent and depth of regular tidal flooding in the future. Projected risks from rising tides lead to reoccurring flooding hazards during monthly high tide events.

Coastal Storm Flooding

These hazard zones depict the predicted flooding caused by future coastal storms. The processes that drive these hazards include (1) storm surge (a rise in the ocean water level caused by waves and atmospheric pressure changes during a storm), (2) wave overtopping (waves running up over the beach and flowing into low-lying areas, calculated using the maximum predicted wave conditions), and (3) additional flooding caused when rising sea levels exacerbate storm surge and wave overtopping. These hazard zones also take into account areas that are projected to erode, sometimes leading to additional flooding through new hydraulic connections between the ocean and low-lying areas. Storm flood risks represent periodic wave impact and flooding. These hazard zones DO NOT consider upland fluvial (river) flooding and local rain/run-off drainage, which likely play a large part in coastal flooding, especially around coastal confluences where creeks meet the ocean (analyzed separately for the Moss Landing area).

Changing Shorelines: Beach and Dune Erosion

These layers represent future dune (sandy beach) erosion hazard zones, incorporating site-specific historic trends in erosion, additional erosion caused by accelerating sea level rise and (in the case of the storm erosion hazard zones) the potential erosion impact of a large storm wave event. The inland extent of the hazard zones represents projections of the future crest of the dunes for a given sea level rise scenario and planning horizon. Erosion can lead to a complete loss of habitat, infrastructure and/or use of properties.

River Flooding

A river flooding vulnerability analysis was completed specifically for this study area to evaluate the cumulative impacts of rising seas and future changes in fluvial discharge within the Gabilan Watershed. The fluvial model estimates localized flooding along the Reclamation Ditch/Gabilan Creek when discharge is restricted behind the Potrero tide gates during high tides. The model results are presented here and the methodology is described within the separate Fluvial Report by ESA.[12]

The future hazards of river flooding due to the predicted increase in fluvial discharge, higher ocean elevations during storms and higher sea level elevations were evaluated for Moss Landing and the Lower Salinas Valley.[13] The predicted increase in fluvial discharge within the Gabilan/Rec Ditch due to more intense rainfall during storms used for this analysis is outlined in Table 3 .

[12] ESA. 2016. *Climate Change Impacts to Combined Fluvial and Coastal Hazards*. May 13, 2016.

[13] ESA. 2016. *Climate Change Impacts to Combined Fluvial and Coastal Hazards*. May 13, 2016.

Table 3. Increases in 100-year Discharge for the Reclamation Ditch System Relative to Historic Period (1950-2000)

EMMISIONS SCENARIO	2030	2060	2100
Medium (RCP 4.5 5th percentile)	20% Increase	40% Increase	60% Increase
High (RCP 8.5 90th percentile)	140% Increase	210% Increase	275% Increase

CoSMoS and H++

The Coastal Storm Modeling System (CoSMoS) is a dynamic modeling approach that has been developed by the United States Geological Survey in order to allow more detailed predictions of coastal flooding due to both future sea level rise and storms integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat) over large geographic areas (100s of kilometers). CoSMoS models all the relevant physics of a coastal storm (e.g. tides, waves, and storm surge), which are then scaled down to local flood projections for use in community-level coastal planning and decision-making. Rather than relying on historic storm records, CoSMoS uses wind and pressure from global climate models to project coastal storms under changing climatic conditions during the 21st century.

Projections of multiple storm scenarios (daily conditions, annual storm, 20-year- and 100-year-return intervals) are provided under a suite of sea-level rise scenarios ranging from 0 to 2 meters (0 to 6.6 feet), along with an extreme 5-meter (16-foot) scenario. This allows users to manage and meet their own planning horizons and specify degrees of risk tolerance. Currently CoSMoS is not available for the study area.

To note, the ESA 2014 models used similar approaches and successfully integrated wave run up, local ocean level changes and sea level rise into their projections and further integrated fluvial discharge from the adjacent watershed. CoSMoS is not yet available for the study area but we assume that the CoSMoS hazard layers will suggest similar vulnerabilities to those documented here under the same climatic assumptions and time horizons.

An extreme scenario called the H++ has also been recommended for evaluation by the Ocean Protection Council. The probability of this scenario is currently unknown, but its consideration is important, particularly for high stakes, long-term decisions. Under the extreme H++ scenario, rapid ice sheet loss on Antarctica could drive rates of sea level rise in California above 50 mm/year (2 inches/year) by the end of the century, leading to potential sea level rise exceeding 10 feet. This rate of sea level rise would be about 30-40 times faster than the sea level rise experienced over the last century.

Since Moss Landing Harbor will likely no longer function under predicted 2100 sea levels of 6.9 feet (due to the loss of the barrier beach), estimating impacts from higher rates of sea level rise (10 feet - i.e. H++ SLR scenario) are not necessary or useful for planning purposes (Figure 4). Also, most adaptation measures identified within this document support the incremental resiliency of in-place harbor infrastructure rather than the development of new coastal amenities and therefore may not be classified as high stakes or long term.

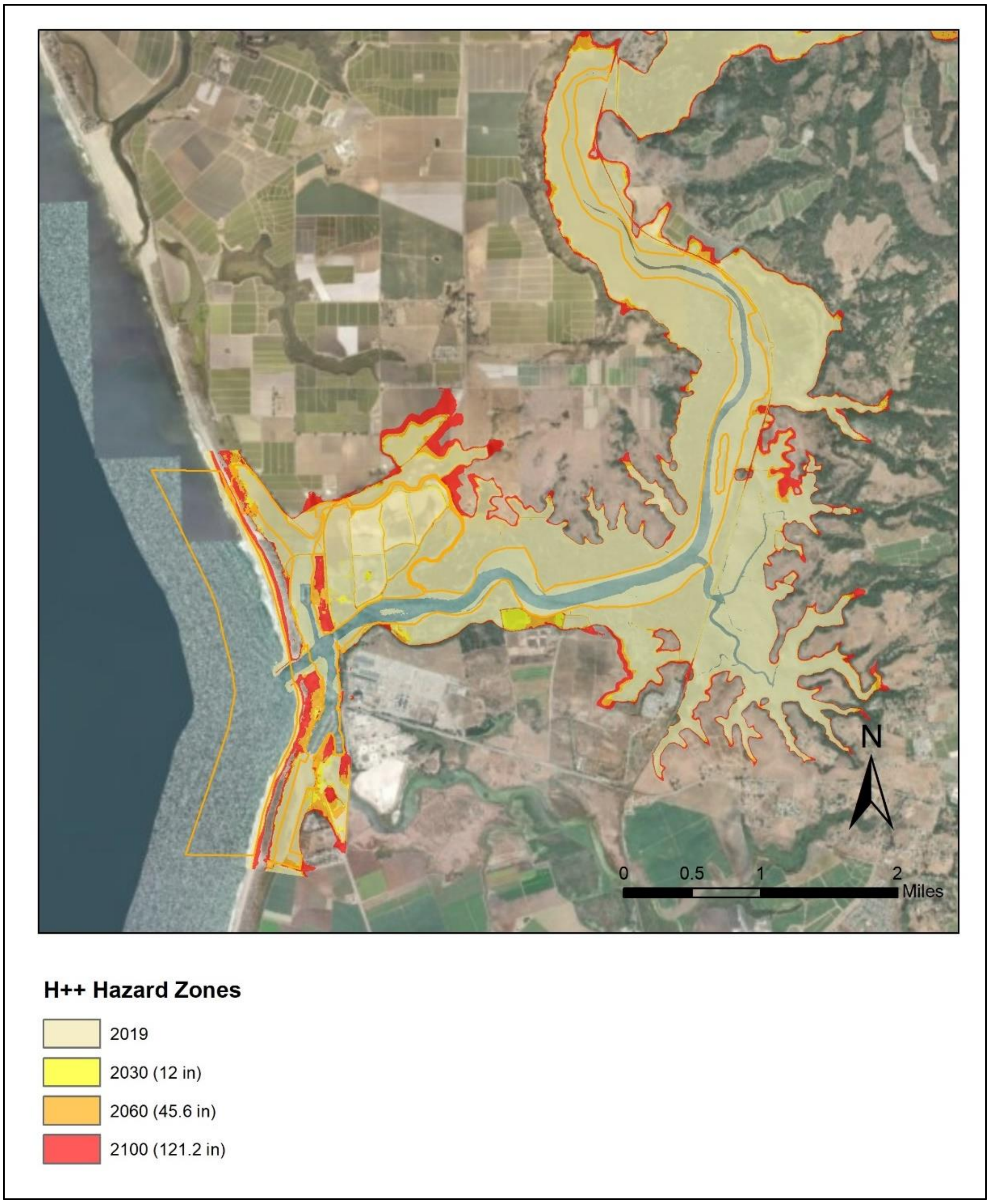

Figure 4. Flooding predicted using extreme rates of sea level rise (H++) for future time horizons.

Moss Landing Harbor Predicted Hazards for 2030

Tidal flooding

Flooding will occur in areas close to current high water (+4 inches) leading to a reduction in service and possible impacts from salt water flooding. Greatest tidal flooding impacts will occur during high tides (king tides) during storms that increase wave energy, local ocean levels, and increased river discharge (Figure 5).

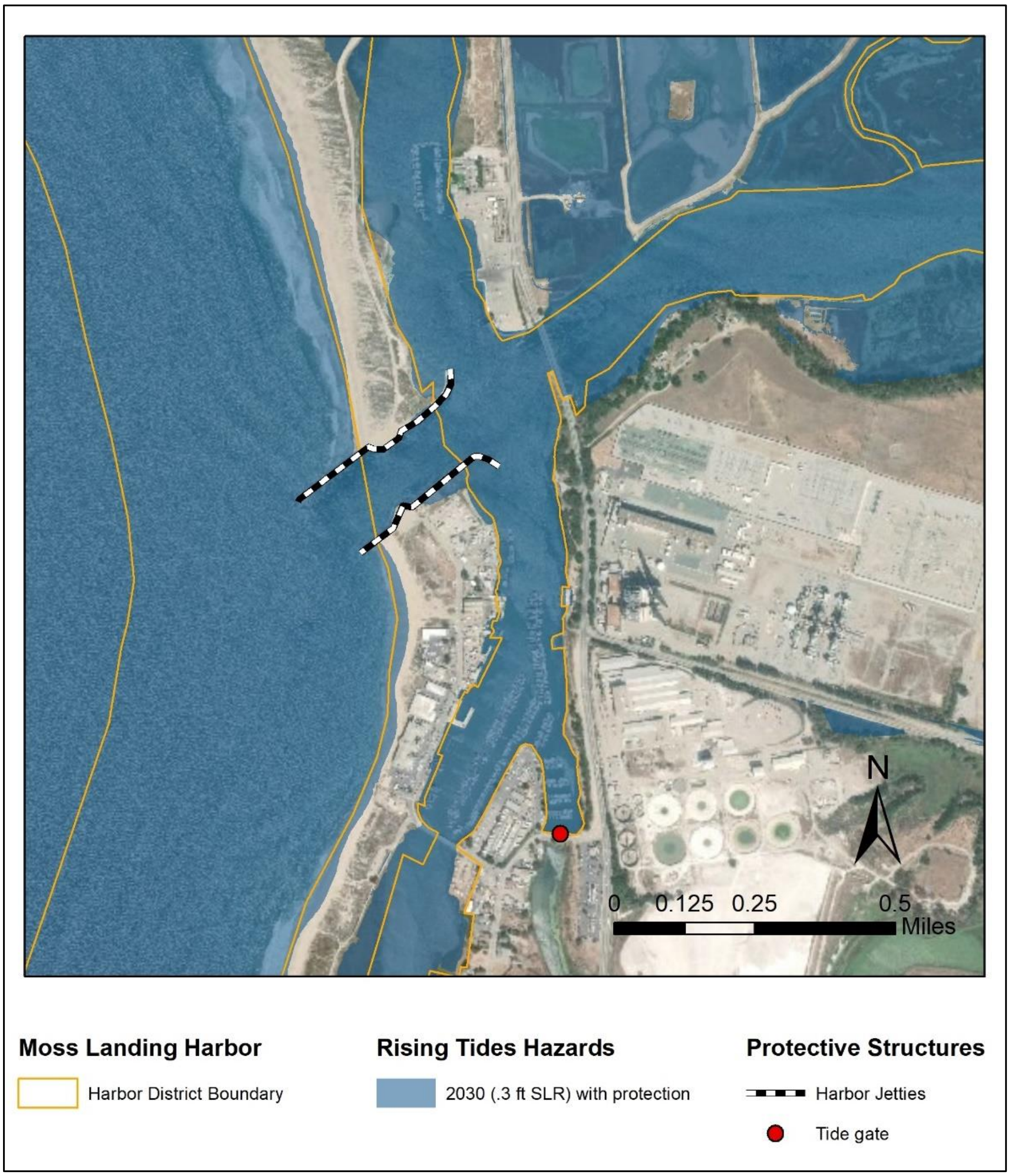

Figure 5. Flooding associated with 2030 increases in sea level (0.3ft)

Storm Flooding

Flooding risks during winter storm events is predicted to increase significantly and lead to the greatest 2030 vulnerabilities. Flooding of the parking areas of South and North Harbor is predicted. Access to the island during storms will be reduced.

Coastal Erosion

Coastal erosion of the sandspit that protects Moss Landing Harbor from ocean waves is predicted to be significant unless protective/adaptive actions are taken. Wave impacts along the beach are predicted to compromise dunes and coastal structures and reduce the long term protection to the harbor.

River/Fluvial Flooding

River discharge during winter storms is predicted to increase. These increases in river flows are predicted to cause localized flooding as stormwater from the watershed meets higher winter ocean elevations in the harbor. Greater velocity discharge from the Old Salinas River into the harbor is likely and may impact infrastructure in its path. Greater sedimentation of the harbor due to greater erosion in the watershed is likely.

Moss Landing Harbor Predicted Hazards for 2060

2060 Rising Tides

Flooding will occur monthly or daily in low-lying areas throughout the harbor leading to a reduction in service and possible impacts from salt water flooding (Figure 6). High tides are predicted to flood various harbor infrastructure and restrict access to docks if adaptive actions are not taken. Flooding of portions of Moss Landing and Sandholdt roads are predicted and will limit access to the harbor and harbor infrastructure on the “island” often. Tidal flooding across harbor granted lands is predicted to lead to inland flooding of the Moss Landing “downtown” area.

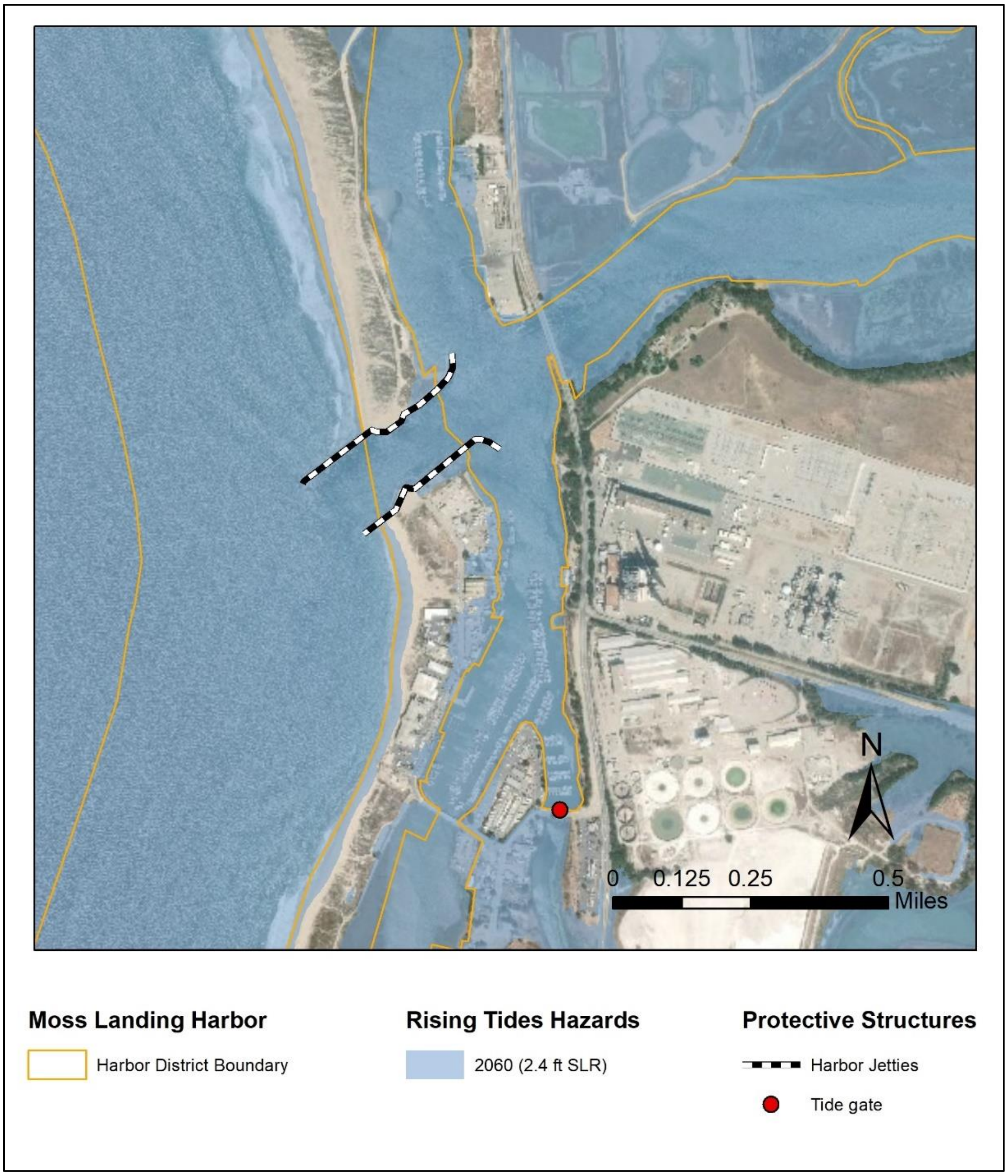

Figure 6. Flooding associated with 2060 increases in sea level (2.4 ft) including access roads to harbor infrastructure and Moss Landing community.

2060 Storm Flooding

Flooding risks during winter storm events is predicted to be significant (Figure 7). Flooding of more than half of the North Harbor land areas is predicted. Wave overtopping of the Island beach/dunes is predicted to be possible, leading to ocean waves (and sand) draining into Moss Landing Harbor. Access to the island during storms will be extremely limited and dangerous.

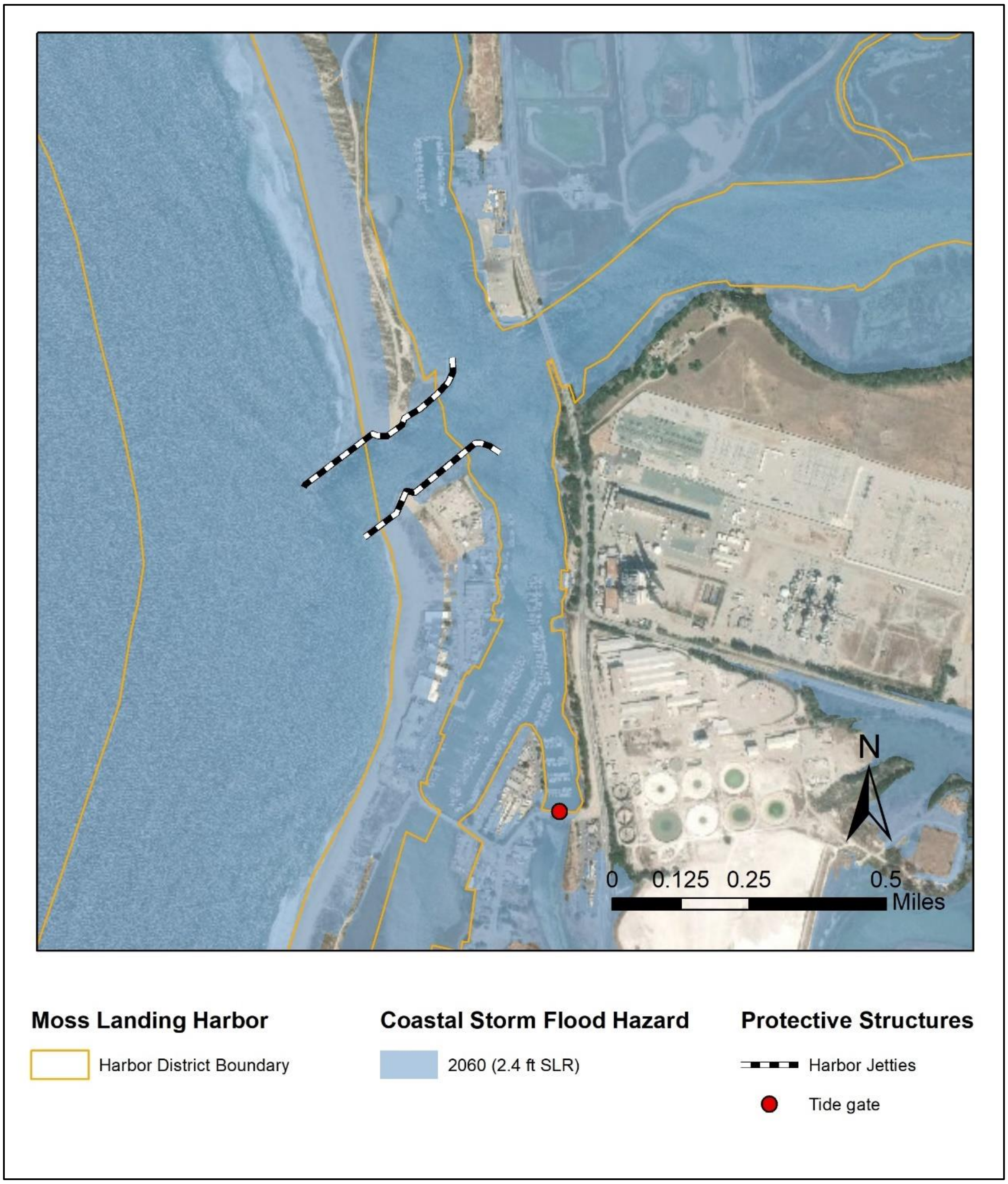

Figure 7. Flooding associated with 2060 storm surge.

2060 Coastal Erosion

By 2060, coastal erosion of the sandspit that protects Moss Landing Harbor from ocean waves is predicted to be significant and possibly jeopardize the harbor unless protective/adaptive actions are taken (Figure 8). Erosion of the dune barrier will likely lead to wave overtopping of the remaining dunes, allowing waves to enter the harbor, leading to vessel and dock damage and significant sedimentation. Failure of dunes are predicted along the entire stretch that parallels the harbor. Dunes adjacent to north harbor and dunes south of Sandholdt road have no structures or coastal armoring to reduce erosion, but also retain some natural dune building and migration capacity lost to development along Sandholdt Road. If dunes are allowed to migrate inland, these areas may retain their protective service.

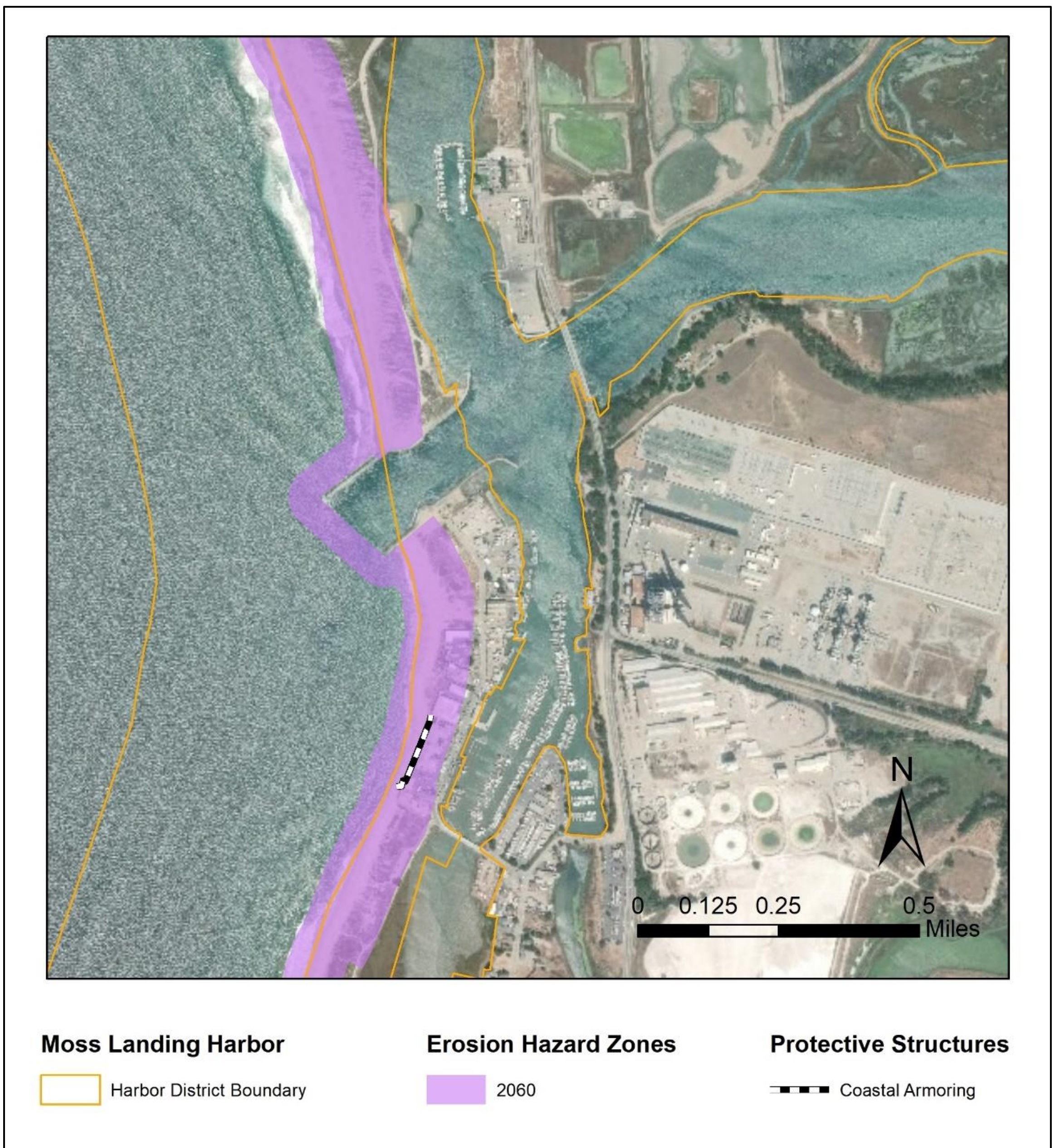

Figure 8. Inland erosion of coastline and loss of beach and dune habitat along the natural and developed sections of the sand spit, jeopardizing future harbor operations.

2060 River/Fluvial Flooding

River discharge during winter storms is predicted to increase. These increases in river flows are predicted to cause localized flooding as stormwater from the watershed meets higher winter ocean elevations in the harbor. Sedimentation of the harbor is also likely to increase due to increased erosion within the watershed during high flow events. Increased discharge velocity under Sandholdt Bridge may impact vessels and harbor infrastructure in south harbor.

Assets at Risk by 2030 and 2060

Public Access

2030: Moss Landing Harbor District provides the public with many unique opportunities to access and enjoy Elkhorn Slough and the Monterey Bay National Marine Sanctuary. Public trust lands granted to the Harbor District include much of Moss Landing tidal beach lands which provides lateral access along the coast between the harbor mouth and Salinas River State Beach. Visitors enjoy spectacular views, fishing opportunities, dog walking, surfing and small boat launching opportunities. The harbor district provides the public with access to 1) recreational fishing and whale watching boats from several public docks, 2) small boat launching for power boats and numerous self-propelled boats, 3) safe harbor berthing for traveling vessels, and 4) marine life viewing from restaurants and public viewing areas. The Harbor also provides private slips for resident vessels of all types.

Of the 11 designated public access areas within the Moss Landing Harbor and Elkhorn Slough, 2 of those access areas are located within the State granted lands. All 11 access areas however do provide public access to the granted lands.

The flooding extent from the combined effects of 2030 sea level rise and coastal storm flooding are predicted to restrict public access to numerous portions of the Moss Landing Harbor District Infrastructure (Figure 9). Specifically, portions of the main parking lot are predicted to be flooded during storms and restrict access to Docks A and B as well as adjacent parking. The small boat launch ramp and parking area of North Harbor are also predicted to be flooded. While access needs of the public will be limited during storm events, access to boat owners with slips in the harbor may be compromised.

Access to some of the harbor infrastructure via the low lying Moss Landing Road (figure 2) will be periodically restricted if the Moss Landing tide gates fail to mute tides to the Moro Cojo Slough. Launch Ramps and dock access areas in the North Harbor are estimated to be resilient to 2030 SLR (Figure 3).

2060: Monthly tidal flooding is predicted to be significant by 2060. Access to much of State granted lands managed by the Harbor District will be restricted during high tides (Figure 9). Flooding is predicted to be extensive within parking areas, dock access ways, launch ramps, and access roads, reducing the use of the harbor significantly and likely posing serious public safety challenges by restricting emergency service vehicles and staff.

Lands along the Moss Landing “island” will be lost as the ocean migrates inland (caused by sea level rise and associated storm waves and coastal erosion) and come into contact with current development, limiting lateral access along the beach. This “coastal squeeze” will likely limit lateral access along the beach between the harbor mouth and Salinas River State Beach.

Access to State granted lands will be restricted during monthly or daily high tides along much of the Island and within the public areas of the South Harbor parking areas. Tidal flooding of the small boat launch ramp and areas around the Elkhorn Yacht club are predicted. Access to north harbor docks is predicted to be restricted.

Public access to the beach and waterways will be compromised due to direct impacts to access locations and from flooding of roads to those locations. Dunes and Moss Landing Beach are predicted to be reduced in width unless they are enabled to migrate inland.

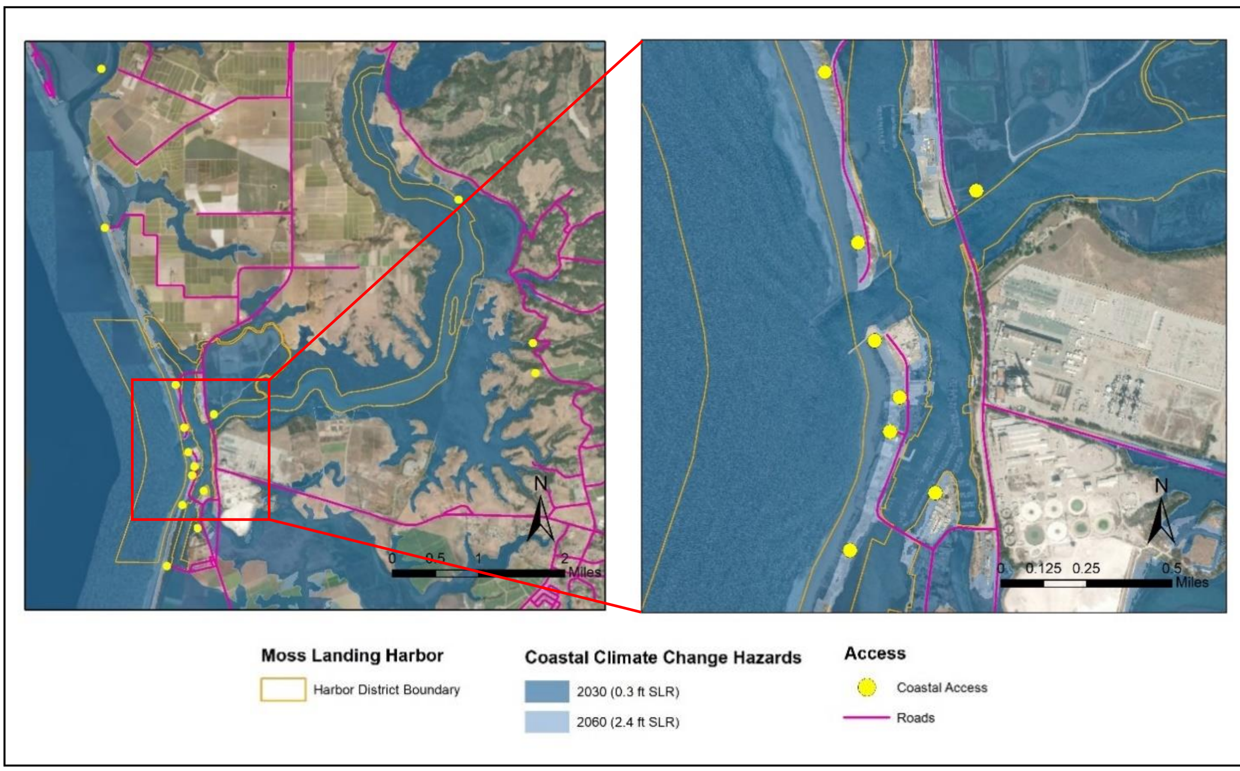

Figure 9. Coastal Access locations restricted by predicted future flooding.

Infrastructure

2030: Three storm drains and two electric meter junction boxes are within the cumulative flood risk areas for 2030. Trash enclosure 32 is located within the flood areas (Table 4, Figure 10 & Figure 11).

2060: 2060 storm and tidal flooding are predicted to compromise large portions of Moss Landing Harbor infrastructure including; two buildings (Cannery Building and Monterey Kayak), half of the storm drains, access to all docks and the used oil containment facility. The Moss Landing Road tide gates on the Moro Cojo Slough are predicted to be overtopped leading to inland flooding. Numerous dock pilings on Dock A are too short to retain floating docks during high tides and winter storms (Table 4, Figure 10 & Figure 11).

Table 4. Harbor infrastructure identified (noted with a number 1) as vulnerable to various SLR hazards during future time horizons

(ER= Erosion, CSF= Coastal Storm Flooding, RT= Rising Tides, TG=Tide Gate)

STRUCTURE	TYPE	ER 2030 (armor)	ER 2060	ER 2100	CSF 2030 (TG)	CSF 2060	CSF 2100	RT 2030 (TG)	RT 2060	RT 2100	FL 2030	FL 2060	FL 2100
Harbor Office	Building						1			1			1
Public Restrooms	Building						1			1			1
Boaters restrooms/laundry	Building						1			1			1
Maintenance Shop	Building						1			1			1
Cannery Building	Building					1	1			1		1	1
ML Storage	Building						1			1			1
ML Storage	Building						1			1			1
Sea Harvest	Building					1	1			1			
North Harbor Building site	Building						1			1			
Old Pot Stop Building	Building						1			1			
MB Kayak	Building					1	1			1			
Restroom Building	Building						1			1			
used oil containment facility	Building/Structure					1	1			1		1	1
Trash Enclosure	Structure					1	1			1			1
Trash Enclosure	Structure				1	1	1		1	1	1	1	1
Launch Ramps	Launch Ramp				1	1	1	1	1	1			
Old Launch Ramps	Launch Ramp				1	1	1	1	1	1			
Electric/ Sewer Lift Station	Lift Station						1						
Sewer Lift Station	Lift Station						1			1			1
Dry Storage	Lot					1	1		1	1		1	1
Maintenance Yard	Lot						1			1			1
Unimproved parking lot	Lot				1	1	1		1	1		1	1
Unimproved lot	Lot						1			1			
Moss Landing Community Park	Park						1			1			1
pier	Pier				1	1	1	1	1	1			
Storm Drain (total)	Storm Drain	0	0	0	7	12	16	2	7	15	2	8	8
Docks (total)	Dock	0	0	1	12	13	13	12	13	13	10	10	11
Electric Meter (total)	Electric Meter	0	0	2	3	6	7	1	5	7	2	5	6

Figure 10. South Harbor infrastructure vulnerable to 2030 and 2060 climate hazards.

Figure 11. North Harbor infrastructure vulnerable to 2030 and 2060 climate hazards.

Commercial Area Adjacent to Harbor

2030: Commercial areas of North Harbor are outside of predicted 2030 hazard areas. Commercial areas of “downtown” Moss Landing and the Moss Landing “island” are predicted to be cut off from highway access during storm events coinciding with high or king tides.

2060: Commercial operations that serve visitors to the Harbor are predicted to be impacted by winter storm flooding. The Elkhorn Yacht Club is estimated to be within tidal and storm flooding elevations. Much of downtown Moss Landing will be flooded if the Moss Landing Tide gates are compromised and across the dry storage area next to the Old Salinas River during winter storms with high river discharge. Commercial, research and industrial infrastructure on Moss Landing Island are vulnerable to frequent flooding and coastal erosion.

Natural Resources/Coastal Habitats

2030: Primary habitats within the State granted lands are subtidal mudflat, deep channel habitat, eel grass beds, tidal beaches and marine mammal haul out areas. These areas are likely resilient to 2030 predicted sea level rise. Adjacent tidal marsh habitat, however, will be submerged by 3-6 inches of additional tidal water, likely leading to the die off of lower portions of the estuarine marsh plain (Figure 12).

Coastal dunes and beaches within and adjacent to Moss Landing Harbor granted lands are predicted to be impacted by greater intensity winter storms that coincide with higher ocean levels. Portions of the beach in front of the Moss Landing sandspit are predicted to have limited lateral access except at low tides (Figure 8). Dune habitat south of Sandholdt Road are similarly likely to see erosion and a reduction in width if the dunes do not migrate inland.

2060: By 2060, lands that are currently intertidal marsh and beach habitat will be flooded and current environmental benefits will be lost as those habitats transition to subtidal landscapes. Much of Elkhorn Slough will become mudflats as marshlands die due to flooding. Sand dunes and beach areas will be lost to erosion and flooding.

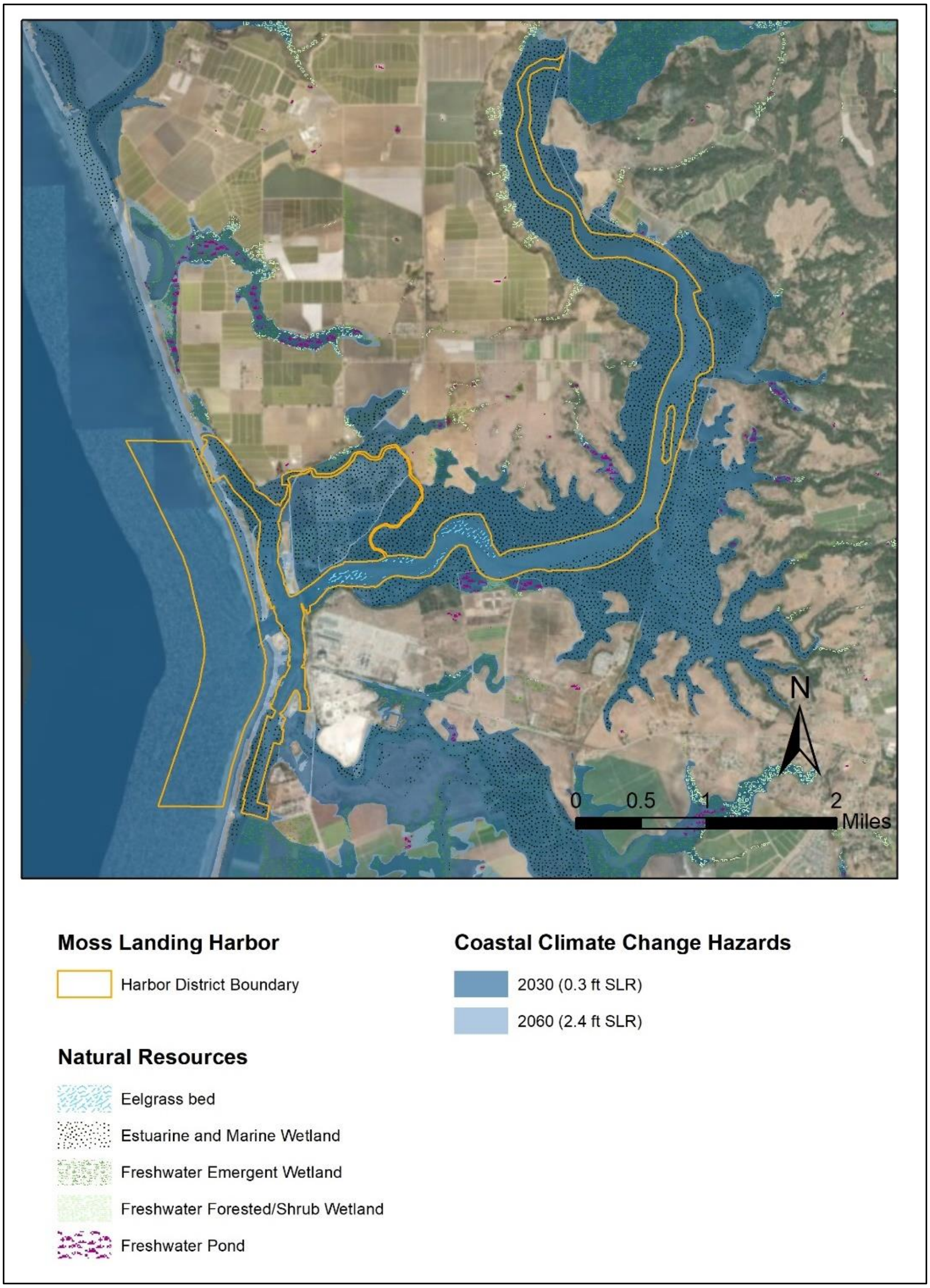

Figure 12. Natural habitats located within the granted lands that may be impacted by changes in water elevation and salinity.

Navigability

2030: Impacts of predicted 2030 risks are anticipated to be associated with restrictions of vessels to land during flooding of harbor parking lots. Some potential limitations to small boat launching are likely during storms. Increased sedimentation of the main channel is likely as tidal marsh transitions to subtidal habitat.

2060: Navigability will be compromised due to loss of access between tidal lands and adjacent public access lands. The harbor mouth jetty is predicted to be overtopped by winter waves. Increased sedimentation from the loss of tidal marshes of Elkhorn Slough and increased flooding in the Salinas Valley will likely lead to increased rates of sedimentation within the harbor. Dock infrastructure will be compromised by higher tides (overtopping older pilings), greater river discharge, and possible dune migration within the north harbor.

Critical Coastal Infrastructure at Risk by 2030, 2060, and 2100

2030 Risks of Coastal Climate Change

1. The flooding extent from the combined effects of 2030 SLR and coastal storm flooding are predicted to restrict access to portions of the main parking lot and restrict access to Docks A and B.
2. The small boat launch ramp and parking area of North Harbor are also predicted to be flooded.
3. Some periodic flooding is predicted for some low lying areas adjacent to the State tidal lands.
4. Access to some of the harbor infrastructure via the low lying Moss Landing Road will be compromised if the Moss Landing tide gates fail to restrict high tides to the Moro Cojo Slough.
5. Launch Ramps and dock access areas in the North Harbor are estimated to be resilient to SLR.
6. Impacts of SLR may lead to significant erosion to Kirby Park launch ramp and parking area.
7. Three storm drains and two electric meters are within the cumulative flood risk areas for 2030. Trash enclosure 32 is located within the flood areas.
8. Commercial areas of North Harbor are outside of predicted 2030 hazard areas. Commercial areas of “downtown” Moss Landing and the Moss Landing “island” are predicted to be cut off from highway access during storm events.
9. Primary habitats within the State granted lands are subtidal mudflat, deep channel habitat, eel grass beds and marine mammal haul out areas.
10. 2030 risks are anticipated to cause restrictions of vessels to land during flooding of harbor parking lots.
11. Limitations to small boat launching are likely during storms.

2060 Risks of Coastal Climate Change

1. Access to much of State granted lands managed by the Harbor District will be restricted during high tides.
2. Flooding is predicted to be extensive within parking areas, dock access ways, launch ramps, and access roads, reducing the use of the harbor significantly and likely posing serious public safety challenges by restricting emergency service vehicles and staff.

3. Lands along the Moss Landing “island” will be lost as the ocean migrates inland (caused by sea level rise and associated coastal erosion) and meet current development, limiting lateral access along the beach.
4. Access to granted lands will be restricted during monthly or daily high tides along much of the Island and within the public areas of the South Harbor parking areas.
5. Access to north harbor docks is predicted to be restricted.
6. Flooding risks during winter storm events is predicted to be significant.
7. Flooding of more than half of the North Harbor land areas is predicted.
8. Wave overtopping of the Island beach/dunes is predicted to be possible leading to ocean waves (and sand) draining into Moss Landing Harbor.
9. Access to the island during storms will be extremely limited.
10. 2060 storm and tidal flooding are predicted to compromise large portions of Moss Landing Harbor infrastructure including; two buildings, half of the storm drains, most electrical meters, access to all docks and the used oil containment facility.
11. The Moss Landing Road tide gates on the Moro Cojo Slough are predicted to be overtopped leading to inland flooding.
12. By 2060, lands that are currently intertidal marsh habitat will be flooded and current environmental benefits will be lost as those habitats transition to subtidal landscapes. Much of Elkhorn Slough will become mudflats as marshlands die due to flooding.
13. Navigability will be compromised due to loss of access between tidal lands and adjacent public lands.
14. The harbor mouth jetty is predicted to be overtopped by winter waves.
15. Increases of sedimentation from the loss of tidal marshes of Elkhorn Slough will likely lead to increased rates of sedimentation within the harbor.

2100 Risks of Coastal Climate Change

1. By 2100, access to all Harbor District infrastructure will be restricted/flooded during daily high tides.
2. Winter storm waves and coastal erosion will likely bisect the sand spit above and below the Sandholdt Bridge, leading to limited use of the granted lands as a safe harbor marina.
3. The community of Moss Landing and Highway 1 will most likely need to be moved out of harm’s way.

The cumulative impacts of sea level rise to harbor infrastructure are shown below in Table 5.

Table 5. Quantification of assets and infrastructure at risk for three time horizons.

STRUCTURE	2030 CUMULATIVE IMPACTS	2060 CUMULATIVE IMPACTS	2100 CUMULATIVE IMPACTS
Harbor Office	0	0	1
Maintenance Shop	0	1	1
Cannery Building	0	1	1
ML Storage	0	0	1
ML Storage	0	0	1
Sea Harvest	0	0	1
North Harbor Building site	0	0	1
Old Pot Stop Building	0	0	1
MB Kayak	0	0	1
Restroom Building	0	0	1
Electric Meters	2	6	7
Storm Drains	3	8	15
Dock Landings	11	12	12
Hazardous Waste	1	2	4
Public Services	0	0	1
Paved Areas	4	6	8

Prioritizing Assets for Adaptation

Considerations for determining adaptive capacity include: 1) continued functionality of infrastructure when not flooded, 2) duration of projected impact (infrequent/short period, monthly, frequent/ongoing), 3) feasibility to increase resiliency of current infrastructure, and 4) functionality of infrastructure given potential loss of access. Adaptations were prioritized based on costs to implement action and continued level of service once adaptation is complete. Adaptive capacity was therefore defined as 1) high if adaptation was cost effective and retained needed level of service, 2) medium if costs were higher but resulting infrastructure was resilient to predicted hazards through 2060, and 3) low if costs were significant and resulting level of service was reduced or impacted by other external hazards (Table 6).

Table 6. Adaptive capacity of various climate risks for 2030, 2060, and 2100.

IMPACTS OF HAZARDS BY TIME HORIZON	FREQUENCY OF HAZARD	DURATION OF IMPACT	FEASIBILITY TO INCREASE RESILIENCY	ADAPTIVE CAPACITY
2030 Risks of Coastal Climate Change				
1. The flooding extent from the combined effects of 2030 SLR and coastal storm flooding are predicted to restrict access to portions of the main parking lot and restrict access to Docks A and B.	Infrequent	Temporary	High	High
2. The small boat launch ramp and parking area of North Harbor are also predicted to be flooded.	Infrequent	Temporary	NA	High
3. Some periodic flooding is predicted for some low lying areas (parking) adjacent to the State tidal lands.	Infrequent	Temporary	Moderate	Moderate
4. Access to some of the harbor infrastructure via the low lying Moss Landing Road (figure 2) will be compromised if the Moss Landing tide gates fail to restrict high tides to the Moro Cojo Slough.	Monthly	Perpetual	Moderate	Moderate
5. Launch Ramps and dock access areas in the North Harbor are estimated to be resilient to SLR (figure 3).	NA			
6. Impacts of SLR have already led to significant erosion to Kirby Park launch ramp and parking area.	Frequent	Perpetual	Moderate	Moderate
7. Three storm drains (7, 11,30) and two electric meters (36 & 37) are within the cumulative flood risk areas for 2030. Trash enclosures 32 is located within the flood areas.	Monthly	Temporary	Low	High
8. Commercial areas of North Harbor are outside of predicted 2030 hazard areas. Commercial areas of “downtown” Moss Landing and the Moss Landing “island” are predicted to be cut off from highway access during storm events.	Infrequent	Temporary	Moderate	Moderate or Low

IMPACTS OF HAZARDS BY TIME HORIZON	FREQUENCY OF HAZARD	DURATION OF IMPACT	FEASIBILITY TO INCREASE RESILIENCY	ADAPTIVE CAPACITY
9. Primary habitats within the State granted lands are subtidal mudflat, deep channel habitat, eel grass beds and marine mammal haul out areas.	NA			
10. 2030 risks are anticipated to cause restrictions of vessels to land during flooding of harbor parking lots.	Infrequent	Temporary	High	High
11. Limitations to small boat launching are likely during storms.	Infrequent	Temporary	High	High
2060 Risks of Coastal Climate Change				
1. Access to much of State granted lands managed by the Harbor District will be restricted during high tides.	Frequent	Temporary	Moderate	Moderate
2. Flooding is predicted to be extensive within parking areas, dock access ways, launch ramps, and access roads, reducing the use of the harbor significantly and likely posing serious public safety challenges by restricting emergency service vehicles and staff.	Frequent	Temporary	Moderate	Moderate
3. Lands along the Moss Landing "island" will be lost as the ocean migrates inland (caused by sea level rise and associated coastal erosion) and meet current development, limiting lateral access along the beach.	Frequent	Perpetual	Low	Low
4. Access to granted lands will be restricted during monthly or daily high tides along much of the Island and within the public areas of the South Harbor parking areas.	Frequent	Temporary	Moderate	Moderate
5. Access to north harbor docks is predicted to be restricted.	Frequent	Temporary	Moderate	Moderate
6. Flooding risks during winter storm events is predicted to be significant.	Frequent	Temporary	Moderate	Moderate
7. Flooding of more than half of the North Harbor land areas is predicted.	Frequent	Temporary	Moderate	Moderate

IMPACTS OF HAZARDS BY TIME HORIZON	FREQUENCY OF HAZARD	DURATION OF IMPACT	FEASIBILITY TO INCREASE RESILIENCY	ADAPTIVE CAPACITY
8. Wave overtopping of the Island beach/dunes is predicted to be possible leading to ocean waves (and sand) draining into Moss Landing Harbor.	Infrequent	Perpetual	Moderate	Low
9. Access to the island during storms will be extremely limited.	NA			
10. 2060 storm and tidal flooding are predicted to compromise large portions of Moss Landing Harbor infrastructure including; two buildings, half of the storm drains, most electrical meters, access to all docks and the used oil containment facility.	Frequent	Perpetual	Moderate	Moderate
11. The Moss Landing Road tide gates on the Moro Cojo Slough are predicted to be overtopped leading to inland flooding.	Frequent	Perpetual	Moderate	Low
12. By 2060, lands that are currently intertidal marsh habitat will be flooded and current environmental benefits will be lost as those habitats transition to subtidal landscapes. Much of Elkhorn Slough will become mudflats as marshlands die due to flooding.	Frequent	Perpetual	Low	Low
13. Navigability will be compromised due to loss of access between tidal lands and adjacent public lands.	Frequent	Temporary	High	Moderate
14. The harbor mouth jetty is predicted to be overtopped by winter waves.	Infrequent	Temporary	Moderate	Low
15. Increases of sedimentation from the loss of tidal marshes of Elkhorn Slough will likely lead to increased rates of sedimentation within the harbor.	Frequent	Perpetual	Moderate	Moderate
2100 Risks of Coastal Climate Change				
1. By 2100, access to all Harbor District infrastructure will be restricted/flooded during daily high tides.	Frequent	Perpetual	Low	Low

IMPACTS OF HAZARDS BY TIME HORIZON	FREQUENCY OF HAZARD	DURATION OF IMPACT	FEASIBILITY TO INCREASE RESILIENCY	ADAPTIVE CAPACITY
2. Winter storm waves and coastal erosion will likely bisect the sand spit above and below the Sandholdt Bridge, leading to limited use of the granted lands as a safe harbor marina.	Frequent	Perpetual	Low	Low
3. The community of Moss Landing and Highway 1 will most likely need to be moved out of harm's way.	Frequent	Perpetual	Low	Low

3. Financial Loss Associated with Sea-level Rise Impacts

Direct Loss of Economic Benefits with Loss of Harbor Services

Several economic studies of the Elkhorn Slough and Moss Landing Harbor have been done that help to characterize the economic benefits provided by the harbor infrastructure and the associated access to coastal and marine environments (Table 7). Pomeroy and Dalton estimated the direct economic value of commercial fishing in Moss Landing to be between $18 million and $25 million per year (based on data from 1999-2001).[14] Six vessels were noted as retaining home port in Moss Landing as commercial passenger fishing vessels in 2007, reported to service just over 100 vessel trips annually with approximately 1000 anglers (2007 data) with adjusted value of approximately $100 per angler trip, or around $1 million.[15]

Table 7. Annual market and non-market valuation of various visitor related access uses of Moss Landing Harbor

ECONOMIC ACTIVITY (2007 DATA)	ECONOMIC VALUE	NON-MARKET VALUE
Commercial Fishing (Landed Value)	$ 24,000,000	N/A
Commercial Passenger Fishing Vessels (Charter Boats)	$ 1,000,000	$ 100,000
Nature-based Recreation (Kayaking & Whale Watching)	$ 7,000,000	$ 5,000,000
Beach going	$ 7,000,000	N/A
Recreational Boating	$ 7,000,000	$ 4,000,000
Boating and vessel related fees	$ 2,000,000	N/A
Research and Conservation (operating budgets)	$ 70,000,000	$ 10,000,000
Total	**$ 118,000,000**	**$ 19,100,000**

While commercial and charter boat fishing have been the long term centers of the local economy, recent studies suggest that research and conservation focused activities likely generate more to the economy currently in terms of gross revenues.[16] The harbor currently supports two highly respected research institutions: Moss Landing Marine Laboratories and the Monterey Bay Aquarium Research

[14] Pomeroy, C. and M. Dalton. 2003. Socio-Economic of the Moss Landing Commercial Fishing Industry. Report to the Monterey County Office of Economic Development.

[15] Miller, N. and J. Kildow. 2007. The Economic Contribution of Marine Science and Education Institutions in the Monterey Bay Crescent. National Ocean Economics Program.

[16] Kildow, J. and L. Pendleton, 2010, Elkhorn Slough Restoration: Policy & Economic Report. National Ocean Economics Program (NOEP). www.oceaneconomics.org

Institute, which combined support more than 420 jobs with annual budgets of more than $67 million. In total, our summary of economic benefits associated with the services and public access provided by the Harbor District through State granted lands is over $118 million annually (Table 7).

Indirect Loss (Non-market Values) of Recreation and Ecosystem Services

In a 2007 study, researchers found that Moss Landing State Beach hosted 200,000 visits annually and attendance at the Salinas River State Beach was approximately 250,000 annually (in 2007).[17] The authors find that beach goers tend to enjoy an average non-market value of roughly $15 per beach visit (year 2006 dollars) which would suggest that the non-market value of beach going at Moss Landing and Salinas River State Beaches could generate on the order of $7 million annually in economic value to beach goers. In another study, estimates that whale watching alone in the state generates more than $40 million in non-market value which can equate to more than $4 million in personal experience value for whale watching from Moss Landing alone.[18]

Table 8. Visitation records for various locations within and around State Granted Lands. (Source: Kildow and Pendleton 2010)

SITE	TOTAL NUMBER OF VISITS	PERCENT VISITATION
Bennet Slough	7	2.3%
Moss Landing North	133	42.9%
Moss Landing South	142	45.8%
Moro Cojo Slough	5	1.6%
SDFP Wildlife Area	63	20.3%
Seal Bend/Rubis Creek	58	18.7%
Moon Glow Dairy	20	6.5%
ESNERR North	35	11.3%
South March	35	11.3%
Visitors Center	67	21.6%
ESNERR North	47	15.2%
North Marsh	5	1.6%
Kirby Park	65	21.0%
Hudson's Landing	5	1.6%

[17] Kildow, J. and L. Pendleton, 2010, Elkhorn Slough Restoration: Policy & Economic Report. National Ocean Economics Program (NOEP). www.oceaneconomics.org

[18] Pendleton, L. 2005. Understanding the Potential Economic Value of Marine Wildlife Viewing and Whale Watching in California. California Marine Life Protection Act Initiative.

Impacts to Recreation

Impacts to coastal access and harbor related recreation were estimated for the two planning horizons of 2030 and 2060 (Table 9). Predicted flooding for the 2030 time horizon will lead to periodic and seasonal restrictions to public access to harbor infrastructure and estuarine and marine areas. Because most flooding impacts will occur during winter storm events and during some non-storm king tide events, restrictions to public access will be limited in numbers and duration (we estimate 15% maximum reduction in public use of beaches). We also anticipate a small reduction in demand for slips due to reductions in level of service during flood events (maximum of 10%). We do anticipate that the loss of estuarine habitat within Elkhorn Slough may lead to a reduction in ecotourism visitation (20%) to the kayak renters located in North Harbor area. Off shore kayak trips should not be impacted. Fishing within the harbor (no non-market valuation data available) was assumed to be unaffected.

By 2060, reduction in the level of service capacity of existing infrastructure is predicted to be significant and may lead to weekly or daily reductions in access to coastal and harbor resources. Unless upgrades are completed, we anticipate a 50% reduction in access and use of the harbor by commercial and privately owned vessels and a 40% reduction in ecotourism related use (because of the variability in access restricted by tidal flooding). Some of these reductions in access can be mitigated through upgrades to existing infrastructure (discussed below).

Impacts to Ecosystem Services

The predicted loss of estuarine marsh habitat due to submergence is expected to have a significant impact on some threatened and endangered species and the loss of important ecological habitat types within Elkhorn Slough. Loss of dune habitat (and resulting adaptive capacity of harbor resources) is also predicted but may be mitigated if coastal dunes are allowed or encouraged to migrate inland. Previous studies suggest that recreation is concentrated in coastal areas near Highway 1 (Moss Landing Harbor and the beaches, Table 8) which are less vulnerable to 2030 hazards.

By 2060 much of Elkhorn Slough will likely transition to a subtidal embayment which may lead to a reduction in ecotourism visitation to the Slough. Similarly, daily flooding of beaches and other natural coastline amenities will reduce visitation to the harbor and adjacent coastline.

Financial Loss of Recreation and Ecosystem Services

Based on our market and non-market resource valuations of the Moss Landing Harbor ($137 million (2007 dollars)) we anticipate a small but real ($3.6 million) impact to the recreation and ecotourism economy by 2030 due to predicted hazards if no adaptation measures are implemented. By 2060 approximately half of the estimated economic valuation will be lost due to the predicted impacts to ecosystem services and daily restrictions in access. Ecosystem and infrastructure vulnerabilities can be mitigated or made more resilient and regional and state partners should work with the Harbor District to prioritize long term management objectives for the harbor (See Table 11 in Section 4). Long term risks (2100) to infrastructure and coastal beaches and dunes will likely make protection of the harbor through the end of the century infeasible and adaptive strategies and retreat plans should be developed to relocate harbor infrastructure inland as needed to provide the necessary level of safe harbor infrastructure in Moss Landing for future boaters.

Table 9. Market and non-market cost implications of reduced level of service and access from predicted climate hazards.

VALUATION	ECONOMIC VALUATION (MARKET AND NON-MARKET)	2030 % SERVICE LOSS	2030 ECONOMIC LOSS	2060 % SERVICE LOSS	2060 ECONOMIC LOSS
Commercial Fishing (Landed Value)	$ 24,000,000	0%	$ -	50%	$ 12,000,000
Commercial Passenger Fishing Vessels (Charter Boats)	$ 1,100,000	0%	$ -	50%	$550,000
Nature-based Recreation (Kayaking & Whale Watching)	$ 12,000,000	20%	$ 2,400,000	40%	$ 4,800,000
Beach going	$ 7,000,000	15%	$ 1,050,000	50%	$ 3,500,000
Recreational Boating	$ 11,000,000	0%	$ -	50%	$ 5,500,000
Boating and vessel related fees	$ 2,000,000	10%	$ 200,000	50%	$ 1,000,000
Research and Conservation (operating budgets)	$ 80,000,000	0%	$ -	50%	$ 40,000,000
Total	**$ 137,100,000**		**$ 3,650,000**		**$67,350,000**

4. Adaptation Opportunities

Proposed Moss Landing Harbor Adaptation Strategies

Below is a description of proposed mitigation/adaptation measures which are intended to address vulnerabilities to existing harbor infrastructure from specific climate risks described in Section 2.

1. Do not build new infrastructure within projected hazard zones that will not be resilient (for the expected life of the infrastructure) to the predicted impacts of that hazard.
2. Upgrade Harbor infrastructure within and adjacent to tidelands to be resilient to 2060 predicted tidal range (>2.6-3.8ft).
    a. Harbor pilings in some areas that have not been upgraded will need to be replaced with taller posts to ensure that tides do not lead to docks overtopping pilings.
    b. Raise or relocate pedestrian walkways, dock access ramps (areas 1, 2 &3) and adjacent infrastructure (oil collection system, garbage enclosure).
3. Raise public parking and access areas of Harbor District property to above the predicted 2060 tidal range.
    a. Raise parking lot areas to above the predicted 2060 tidal range (>2.6-3.8ft). (See Figure 13)
    b. Access/launch ramps and other infrastructure should be upgraded in coordination with adjacent efforts to raise parking and access areas above 2060 tides.
4. Design and build low relief berms (with drainage infrastructure) along harbor waterfront and restore coastal beach and dunes to help reduce winter storm flooding to Harbor district property and adjacent roads and infrastructure.
    a. Design and construct (in partnership with the Monterey County, CalTrans and Moss Landing Community) low relief berms along waterfront areas where storm flooding is predicted to overtop and flood inland low-lying roads and properties. (See Figure 13)
    b. Upgrade storm drains to enhance drainage during rainstorms with high tides (king tides).
    c. Work with US Army Corps of Engineers and Monterey Bay National Marine Sanctuary (and other regulatory agencies) to investigate beach and dune nourishment opportunities for harbor dredge materials to increase SLR resiliency.
    d. Continue to support dune restoration and resiliency efforts on Salinas River State Beach sand dunes (Figure 13).
    e. Define inland zones to support dune migration (while maintaining harbor channel functions) needed to maintain a minimum dune barrier width (Figure 14a).

5. Work with Monterey County and Moss Landing Community to ensure road access to harbor infrastructure and docks.
    a. Continue to participate in the Moss Landing Community Plan development process and ensure that County services including roads and bridges and utilities are maintained, upgraded or relocated in ways that ensure continued access to and use of harbor infrastructure through 2060.
    b. Upgrade Moss Landing Road tide gates to enhance drainage during rainstorms with high tides (king tides).
6. Draft long range plan in partnership with Monterey County to relocate the harbor infrastructure (in tandem with the Moss Landing community, local roads and highway alignment) inland to serve 2100 community needs. Negotiate modified tidal lands lease agreement with State Lands Commission.
    a. Establish a long range planning effort within the Moss Landing Community Plan process to identify needed coastal retreat strategies and rezone areas for future development inland of mapped hazard areas (Figure 14b). Investigate new opportunities to relocate Moss Landing Harbor inland along the Elkhorn or Moro Cojo sloughs as coastal dunes fail or migrate inland.
    b. Ensure that County actions (road and bridge replacements) and state agency programs and policies support harbor district needs to re-locate new berthing inland within Elkhorn Slough (East of the current location of Highway 1), in order to continue safe harbor services to the citizens of California.

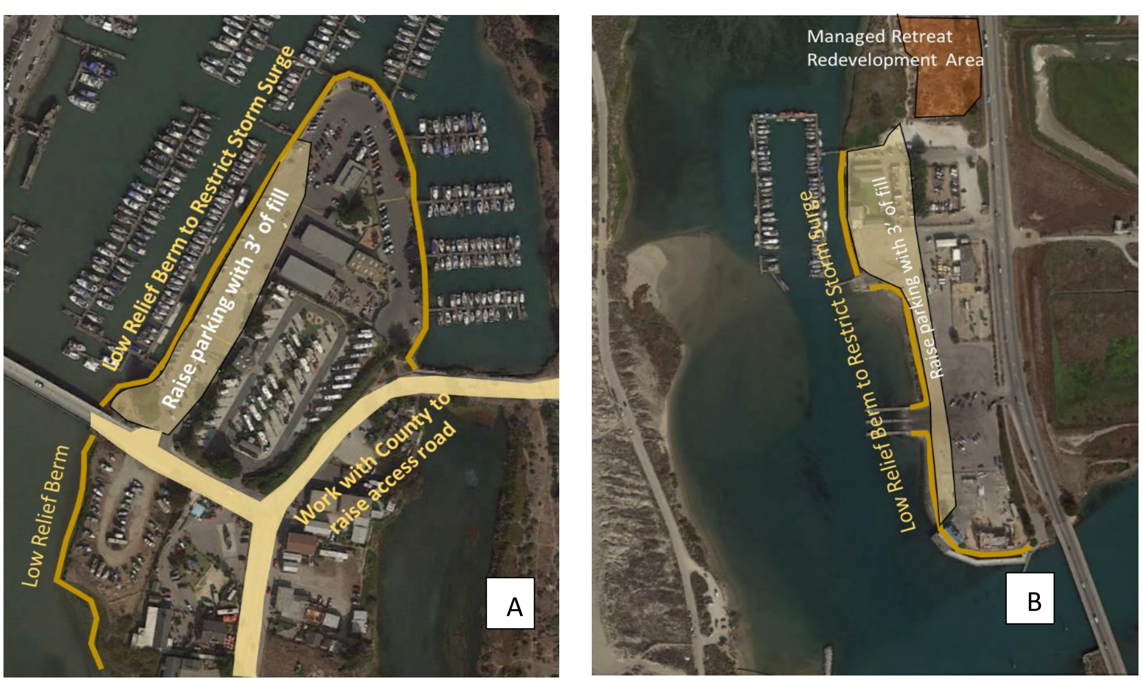

Figure 13. Maps of adaptation, resiliency and retreat planning areas including harbor berm to reduce storm related flooding and raising of parking/ public areas to reduce tidal flooding A) South Harbor, B) North Harbor.

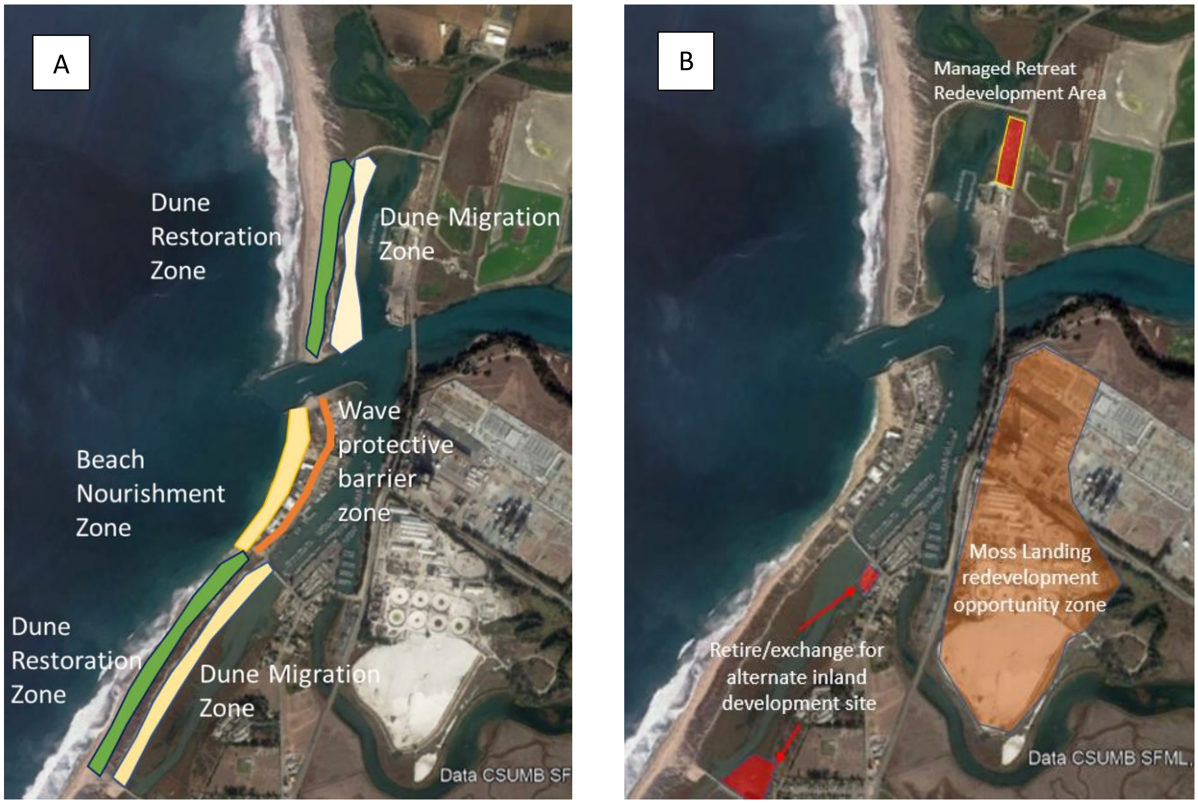

Figure 14. Maps of (A) areas for recommended coastal dune and beach management zones to increase resiliency of natural dune barrier and work with ML island property owners to develop a storm surge barrier into new and existing development and (B) possible areas in harbor ownership where development opportunities could be retired and exchanged for development in areas resilient to 2060 hazards (Moss Landing community redevelopment opportunity zone also noted although outside of harbor district control).

Timeframe of Implementation of Measures

Table 11 lists recommended timeframes for initiation and completion of various adaptation, protection and planning efforts needed to be completed by the Harbor District, Monterey County and private land owners to address predicted coastal climate hazards. Infrastructure upgrades identified within this hazard evaluation focus on increasing the elevation of parking and dock access ways (Figure 13) and the enhancement and management of coastal boundaries including dunes and beaches and harbor waterfront that provide resiliency to predicted flooding (Figure 14).

Monitoring of Sea-level Rise Impacts and Adaptation Strategies

Climate Impact Monitoring Strategy

It is recommended that the Harbor District adopt a simple tracking system to document impacts to infrastructure and reductions in levels of service associated with coastal flooding, erosion and other related coastal climate change hazards. Tracking should document 1) impacts that require replacement, repair or upgrades to harbor infrastructure and 2) flooding and other storm related events which restrict access to harbor infrastructure and public access to the harbor, Elkhorn Slough, beaches and Monterey Bay National Marine Sanctuary.

Regional Planning in Place to Address Sea-level Rise and Climate Change

Moss Landing Community Plan

The Moss Landing Community Plan and Coastal Implementation Plan, both of which are a part of the Monterey County Local Coastal Program, are currently being updated to provide a comprehensive planning framework to improve and enhance the Moss Landing community. This plan is being prepared by the Monterey County Resource Management Agency – Planning with the input and assistance from the community, stakeholders, planning & environmental consultants and associated agencies.

Integrated Regional Water Management Program

Integrated regional water management (IRWM) is an approach to water resource management in California that is being strongly promoted by the State as a way to increase regional self-sufficiency. IRWM offers an approach for managing the uncertainties that lie ahead, particularly in light of climate change. The IRWM planning process brings together water and natural resource managers, along with other community stakeholders, to collaboratively plan for and ensure the region's continued water supply reliability, improved water quality, flood management, and healthy functioning ecosystems—allowing for creative new solutions and greater efficiencies. The Greater Monterey IRWM Plan has been developed to fulfill the goals of IRWM planning in this region and to provide eligibility for State IRWM grant funds.

Elkhorn Slough Tidal Wetland Recovery Plan

With fifty percent, or 1,000 acres, of Elkhorn Slough's salt marshes being lost over the past 150 years and the ongoing marsh loss and habitat erosion, the Elkhorn Slough Tidal Wetland Program was formed. This unique program is a collaborative effort to develop and implement strategies to conserve and restore estuarine habitats in the Elkhorn Slough watershed. For the past several years, stakeholders and scientists participating in the Elkhorn Slough Tidal Wetland Project (TWP) have evaluated the pros and cons of different restoration alternatives for the estuary. The main channel and tidal creeks in Elkhorn Slough have undergone extensive erosion due to tidal scour following the opening of an artificial mouth to the estuary in 1946 to accommodate Moss Landing Harbor. The larger estuarine mouth also has contributed to dieback of salt marsh habitat in the slough. Tidal Wetland Project investigations explored whether a single large fix at the mouth of the estuary, effectively shrinking the mouth size, would benefit overall ecosystem health. The decision was that no large scale action should currently be undertaken at the mouth of the estuary, because of potential risks to water quality, negative impacts to recreational boating, and uncertainty about benefits to salt marsh habitat. However, smaller scale actions have been taken including the Parson's Slough sill, and raising the elevation of the Minhoto Marsh elevation with sediment from the Pajaro River.

Estimate of Financial Costs of Sea-level Rise Adaptation

Storm Cleanup, Replacement or Repair Costs

Costs associated with future cleanup after storm events is difficult to anticipate and budget. Previous cleanup and repair efforts have been completed by the Harbor District and often include repairs to docks due to fluvial discharge and storm surge, dredging due to erosion from the watershed, and road and parking lot cleanup due to storm surge and flooding. Such costs are anticipated to increase as storm events increase in frequency and intensity.

Anticipated Costs of Adaptation/Mitigation Measures, and Potential Benefits of Such Strategies and Structures

Costs to implement the 2030 and 2060 adaptation efforts was estimated with input from Harbor District Staff (Table 10 and Table 11). Costs include design, planning, permitting and construction activities. No adaptation strategies required the purchase of new properties but many adaptation actions needed to retain operations of the harbor are the responsibility of state and county agencies. Specifically, CalTrans is responsible for continued operations of Highway 1 (and currently studying long term management of the corridor in reference to predicted SLR hazards) and Monterey County which is responsible for local roads, bridges and tide gates.

Table 10. Adaptation Costs for 2030 and 2060 time horizons.

TIME HORIZON	ADAPTATION APPROACH	ADAPTATION COSTS
2019-2030	Adapt	$2,100,000
	Plan	$250,000
	Protect	$1,700,000
	2030 Total	***$4,050,000***
2030-2060	Adapt	$13,000,000
	2060 Total	***$13,000,000***
	Total	**$17,050,000**

Anticipated costs to relocate infrastructure and work with county agencies to upgrade roads is anticipated to cost approximately $4 million (Table 10). These activities are expected to reduce loss of service of Harbor infrastructure and help maintain access to boats during flooding, and estimated market and non-market cost of approximately $3.6 million annually or approximately ten times return on the investment to the boating community. Costs to raise parking and access ways, and construct storm surge protection around the harbor is anticipated to cost $17 million but will reduce market and non-market losses of approximately $67 million annually by 2060 (Table 9).

Costs to construct extensive sea walls or rip-rap needed to protect the harbor from wave overtopping of the coastal beach strand were not estimated but were assumed to be only partially effective and would likely be cost prohibitive when compared with relocating marina boat slips inland, away from wave hazards.

Cost Savings

Much of the costs to implement the actions was attributed to permitting and planning as well as state requirements to pay prevailing wages. Significant reductions in described costs could be made if permitting costs were reduced significantly and prevailing wage requirements were suspended for SLR mitigation and adaptation activities. Integration of these identified adaptation actions could be integrated into the Moss Landing Community plan and thus integrated with the North Monterey County Local Coastal Plan. Integration into the LCP may help to reduce permitting costs if the State adopts policies that support streamline permitting of SLR adaptation strategies outlined in adopted LCPs.

Table 11. Adaptation Strategy Implementation Timeline and Cost

TIME HORIZON	ADAPTATION APPROACH	ACTION	RELATIVE COST	SIZE OF EFFORT	ESTIMATED COST
2019-2030	Adapt	Upgrade older dock pilings with taller pilings that can withstand predicted 2060 tidal range.	Mid	50 Pilings	$700,000
		Move trash and oil recycling enclosures out of storm flood hazard area.	Low	2 enclosures	$1,000,000
		Investigate alternative routes to north harbor docks that will provide better access during winter storm flooding.	Low	1 access location	$400,000
	Plan	Work with Monterey County and Coastal Commission to transfer development rights to inland or more resilient areas.	Low	3 parcels	$250,000
		Work with Monterey County and Moss Landing Marine Labs to ensure proper functionality of Moss Landing Road/Moro Cojo Slough Tide Gates to minimize flooding to "downtown".	Mid	Three culverts and tide gates with upgrades to road	County
		Work with Elkhorn Slough NERR to identify marsh plain resiliency options (possibly using appropriate dredge spoils) to retain marsh habitat areas and reduce slough erosion and harbor siltation.	Low	1,000 Acres	N/A
	Protect	Design and construct (in partnership with Monterey County, CalTrans and Moss Landing Community) low relief berms along waterfront areas where storm flooding is predicted to overtop and flood inland low-lying roads and properties. Upgrade storm drains to enhance drainage during rainstorms with high tides (king tides).	Mid	650 Linear Feet (North Harbor) 1600 Linear Feet (South Harbor) 500 Linear Feet (OSR Storage)	$1,200,000
		Continue to support dune restoration and resiliency efforts on Salinas River State Beach sand dunes.	Low	25 acres	State Parks
		Work with Monterey County, State Lands Commission, US Army Corps of Engineers, and Monterey Bay National Marine Sanctuary to encourage beach nourishment on developed sections of the Moss Landing sandspit using appropriate harbor dredge spoils.	Low	6 acres of beach area	$500,000

TIME HORIZON	ADAPTATION APPROACH	ACTION	RELATIVE COST	SIZE OF EFFORT	ESTIMATED COST
2030-2060	Adapt	Upgrade access ramps and other infrastructure in coordination with adjacent efforts to raise parking and access areas above the predicted 2060 tidal range (>2.6-3.8ft)	Low	12 access landings	$1,000,000
		Raise parking lot areas, pedestrian walkways, dock access ramps (areas 1, 2 &3) and adjacent infrastructure (oil collection system, garbage enclosure) to above the predicted 2060 tidal range (>2.6-3.8ft). (See Figure 13)	High	1 Acre (North Harbor) 1.5 Acres (South Harbor) 1.25 Acres (Old Salinas Storage)	$10,000,000
		Move vulnerable infrastructure (trash enclosures, restrooms) away from hazard areas.	Mid	10 pieces of infrastructure	$2,000,000
		Work with Monterey County to raise Moss Landing and Sandholdt Roads to maintain access during high tides and winter storms.	High	2000 Linear Feet	County
	Plan	Ensure that County services, including roads and bridges, are maintained, upgraded or relocated in ways that ensure continued access to harbor infrastructure through 2060.	High	2000 Linear Feet	County
		Work with CalTrans to ensure highway service to Moss Landing either in current or new alignment. Investigate Dolan Road as community access road if Highway 1 is moved inland.	Very High	4 miles of highway	State
2060-2100	Adapt	Establish a long range planning effort within the Moss Landing Community Plan process to identify needed coastal retreat strategies and rezone areas for future development inland of mapped hazard areas. Investigate new opportunities to relocate Moss Landing Harbor inland along the Elkhorn or Moro Cojo Sloughs as coastal dunes fail or migrate inland.	Mid	Complete Redevelopment	N/A

5. Conclusion

To ensure continued harbor operations through 2060 CCWG, with input from the Harbor District, has identified a number of necessary adaptation actions (raising of parking and dock access) that will help increase the resiliency of infrastructure and continue to provide an expected level of service and access. The costs to build/construct these activities are expected to be spent as the reduction in service is documented (i.e. environmental triggers). By 2060 access to harbor infrastructure (and therefore State Granted Lands) will be greatly reduced due to monthly or daily tidal flooding. Adaptation and resiliency measures taken by the Harbor District will only be effective if Monterey County, CalTrans and regional utilities, California State Parks, and private land owners along the Island sandspit take concurrent actions to adapt current infrastructure and maintain resiliency. Road, bridge and tide gate infrastructure must be maintained and upgraded if the Harbor is to remain viable through 2060. Coastal resilience planning is needed to increase resilience to 2060 wave overtopping of the Island and will need to be coordinated and a plan agreed to by the County, State (specifically the Coastal Commission), and private land owners on the island.

The hazards predicted to occur sometime between 2060 and 2100 are significant and likely unsurmountable for the harbor to withstand and remain operational within its current layout. Retreat of harbor infrastructure inland within the Elkhorn and Moro Cojo sloughs is likely needed if the Moss Landing Harbor is to remain a viable California safe harbor.

State and County funding needed to retain access to Harbor infrastructure and utilities will need to be identified before the Harbor District can invest in necessary upgrades. Such retreat and relocation decisions will need to be made in consult with State Lands and California Boating and Waterways staff who will need to prioritize future expenditures needed to retain safe boating along the California Coast.

Exhibit F.6

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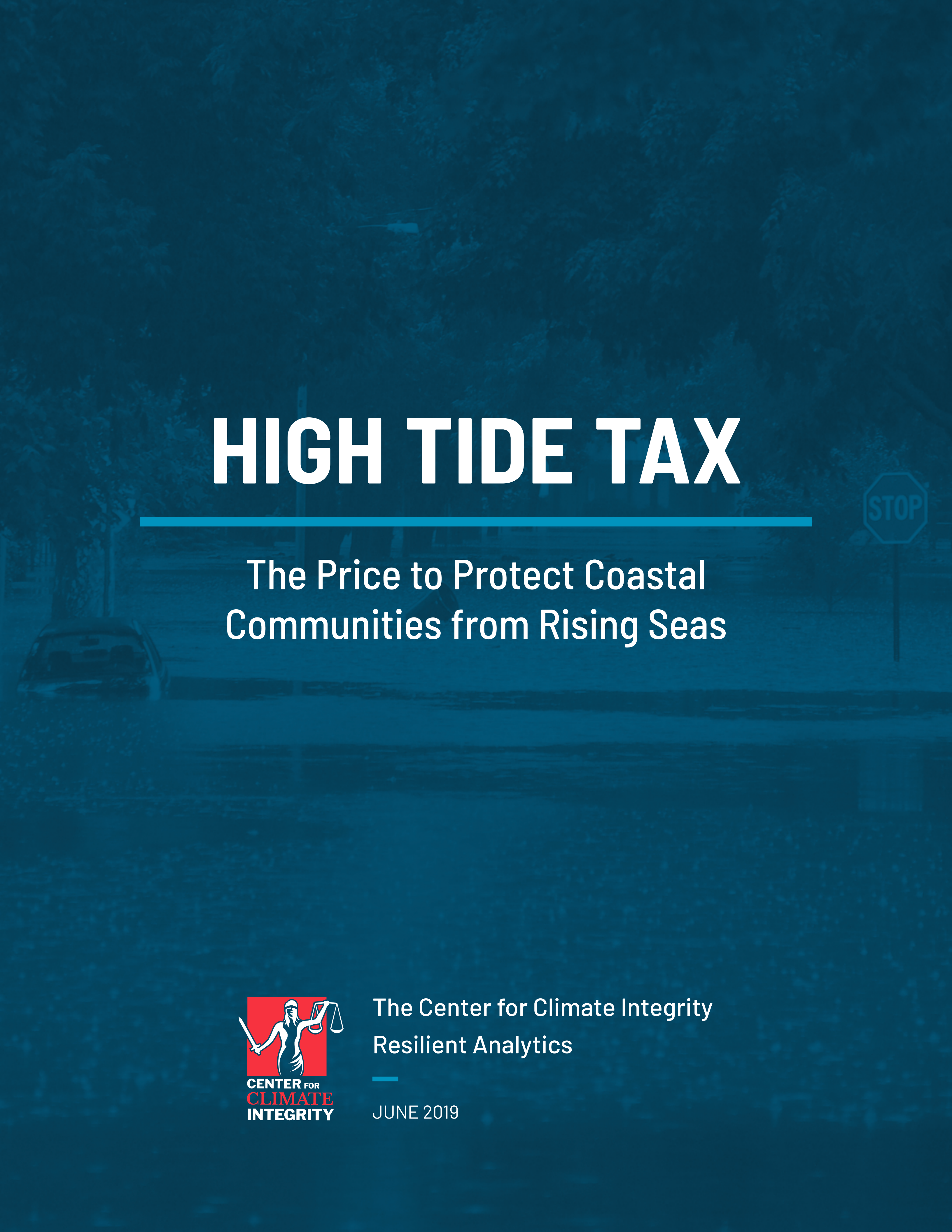

HIGH TIDE TAX

The Price to Protect Coastal Communities from Rising Seas

CENTER FOR CLIMATE INTEGRITY

The Center for Climate Integrity
Resilient Analytics

JUNE 2019

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About CCI

The Center for Climate Integrity is a project of the Institute for Governance and Sustainable Development. The Center for Climate Integrity supports litigation and advocacy to hold the fossil fuel industry accountable for their fair share of the escalating costs of adapting to climate change. Through community engagement, communications, and strategic legal support, CCI works to elevate the idea that taxpayers should not shoulder the burden of climate costs alone. Instead, those who contributed to the climate crisis — and who downplayed the monumental risks they knew their products would create — should help communities with those growing bills.

Executive Summary

The United States faces more than $400 billion in costs over the next 20 years, much of it sooner, to defend coastal communities from inevitable sea-level rise. This is approaching the cost of the original interstate highway system and will require the construction of more than 50,000 miles of coastal barriers in 22 states in half the time it took to create the nation's iconic roadway network. More than 130 counties face at least $1 billion in costs, and 14 states will see expenses of $10 billion or greater between now and 2040.

These costs reflect the bare minimum coastal defenses that communities need to build to hold back rising seas and prevent chronic flooding and inundation over the next 20 years. They represent a small portion, perhaps 10 to 15 percent, of the total adaptation costs these local and state governments will be forced to finance during that time and into the future.

The question is, will taxpayers be on the hook for all the costs of climate adaptation, or will polluters be forced to pay their fair share?

This looming climate and financial threat exists for every coastal community, regardless of size, population, or financial position, and includes large cities such as New York and Miami and small communities like Dames Quarter, MD and Topsail Beach, NC.

For hundreds of small coastal and tidal communities identified in the report, the costs will far outstrip their ability to pay, making retreat and abandonment the only viable option unless enormous amounts of financing emerge in a very short period of time. Yet even retreat comes at a substantial cost, as courts have begun to rule that governments that fail to protect private property must compensate property owners for the value of the property that is abandoned.

As just one example of the scope and gravity of this problem, in 19 small, mostly unincorporated communities, the cost of seawalls to protect property and infrastructure from a moderate amount of sea level rise by 2040 is more than $1,000,000 per person. It seems fair to say that these communities will not be defended, although those decisions will all be made locally. In 43 communities the cost is more than $500,000 per person, and in 178 communities the cost of basic coastal defenses is more than $100,000 per person.

In reality, the situation could be much worse. This analysis is based on modest sea-level rise projections that assume some reductions in carbon emissions (RCP 4.5, described below). Seas could easily rise more than we project in this study, but they are very unlikely to rise less. And we only assumed protections for a one-year storm (the event that is virtually certain to occur every year), even as one in 100 and one in 500-year storms strike the coast with alarming frequency.

This conservative approach is by design, and is intended to shine a light on near-term costs and choices that cannot be avoided. Unlike many studies that look at sea-level rise in the year 2100 and assume a higher level of ongoing emissions, we purposefully analyzed more moderate and immediate scenarios to direct the policy discussion toward decisions that need to be made right now.

In many states, including Florida, Virginia, and South Carolina among others, these discussions are well underway. But even where communities are beginning to plan for climate impacts, the statewide costs of basic coastal and tidal protection are most often not publicly known.

Florida is by far the most heavily impacted state, with costs reaching nearly $76 billion statewide, 23 counties facing at least $1 billion in seawall expenses alone (and often far greater price tags according to local estimates), and 24 communities where building just this rudimentary level of coastal protection will cost more than $100,000 per person.

Climate impacts do not respect partisan boundaries, with Republican and Democratic congressional districts hit roughly evenly by 2040: Republican congressional districts will incur $224 billion in seawall costs, while Democratic congressional districts will incur $192 billion. There are 71 districts facing more than $1 billion in seawall expenses by 2040: seven of the top 10 and 24 of the top 40 are currently represented by Republicans. Overall, 100 are represented by Democrats and 371 are represented by Republicans. Though Republican congressional districts make up only 27% of the congressional districts that will incur costs by 2040, they account for 54% of the total national cost.

For complete state, county, city and congressional district rankings, see our rankings webpage at climatecosts2040.org/rankings.

1 Including vacant seat NC-3, previously held by a Republican congressman.

Recommendations

The failure of the American public and its elected representatives to come to grips with the massive costs of climate adaptation (not to mention disaster recovery, which is not addressed here), is perhaps the most delusional form of climate denial we currently face.

Climate threats are real, they are here today, and the unaddressed financial costs of adaptation loom large and are unavoidable. Protecting America from climate change will be the most all-encompassing transformation of civil society ever undertaken, whether we engage the task wisely, or deny it and delay well past when we should act, as we are wont to do with all things climate related. Either way, climate adaptation will touch every sector of society and every citizen, requiring all the skills and resources we can muster ¬– in this case steel, cement, engineers, planners, road builders and much more – in an unprecedented reinvention of the world we live in.

And yet even then, none of this will come to pass unless everyone pays their fair share.

As things stand, oil and gas companies and other climate polluters who knew their products caused climate change at least 50 years ago, and then masterminded an exquisitely effective denial campaign for 30 years, are paying none of these costs. And their position, as expressed in courtrooms across the country, is that they should continue to pay nothing at all.

That simply cannot stand. Regardless of your political persuasion or your views on energy policy or climate change, there is no avoiding the conclusion that the companies that made and promoted the products that they knew would irrevocably and radically alter the global climate, and then denied it, must pay their fair share to help the world deal with it. Failing to hold polluters to this basic responsibility would be to knowingly bankrupt hundreds of communities, standing idly by as they are slowly and inexorably swallowed up by the sea.

Introduction

Coastal communities worldwide are facing the daunting challenge of protecting their citizens and their infrastructure – roads, bridges, airports, rail lines, port facilities, sewage treatments systems, drinking water supply systems, storm drainage systems, and public utilities – from rising sea levels.

This study provides the first estimate for the contiguous United States of the costs associated with armoring areas of the coast that contain public infrastructure and that are projected to be flooded by sea-level rise. While a variety of infrastructures are at risk due to the impacts of climate change, the primary focus of this study is estimating the costs of ensuring that roads, rails, and other public infrastructure are protected from the predicted near-term and long-term impacts of sea-level rise under moderate, not worst case, emissions scenarios. The study did not specifically identify homes and other private property for protection, but instead relied on roads as a proxy for areas with developed private assets.

The Center for Climate Integrity partnered with Resilient Analytics, an engineering firm specializing in climate adaptation, to generate the estimated costs of constructing seawalls to protect public infrastructure in the contiguous United States from sea-level rise. By pairing a sophisticated sea-level rise model[2] with 1-year storm surge estimates,[3,4] as well as the NOAA Medium Resolution Shoreline dataset, we have produced planning-level cost estimates for different years (2040, 2060, 2100) under two different future emissions scenarios, with and without a 1-year storm surge for states, congressional districts, counties, as well as cities, towns, villages, and census designated places (unincorporated population centers), which we collectively refer to as *communities*. The complete dataset is available for download at www.climatecosts2040.org.

2 Kopp, Robert E., Robert M. DeConto, Daniel A. Bader, Carling C. Hay, Radley M. Horton, Scott Kulp, Michael Oppenheimer, David Pollard, and Benjamin H. Strauss. "Evolving understanding of Antarctic ice-sheet physics and ambiguity in probabilistic sea-level projections." *Earth's Future* 5, no. 12 (2017): 1217-1233.

3 Tebaldi, Claudia, Benjamin H. Strauss, and Chris E. Zervas. "Modelling sea level rise impacts on storm surges along US coasts." *Environmental Research Letters* 7, no. 1 (2012): 014032.

4 Buchanan, Maya, Kopp, Robert, Oppenheimer, Michael, Tebaldi, Claudia. "Allowances for evolving coastal flood risk under uncertain local sea level rise." *Climatic Change*, 137, 3-4, 347-362 (2016).

Sea-Level Rise

Since 1900, global mean sea-level has risen about 8 inches,[5] but this has not been a steady progression, nor has it been the same in every location. The rate of sea-level rise began to increase dramatically in the late 20th Century. Since 1990, the rate of sea-level rise has increased to about twice the rate of the last century and is continuing to accelerate.[6,7]

Global warming contributes to sea-level rise in several ways. As the oceans warm from rising air temperature, seawater expands, takes up more space, and the oceans rise to accommodate this physical expansion. This process is known as *ocean thermal expansion*, and accounts for about 50% of the increased volume of the world's oceans over the past 100 years. The remaining sea-level rise of the past century has been the result of melting mountain glaciers (about 25%) and Antarctic and Greenland ice sheet loss (about 25%).[8,9]

There is a delay between rising air temperatures and sea-level rise. Ocean thermal expansion and ice loss occur on timescales slower than the rate at which air temperature increases in response to rising atmospheric CO_2 concentrations. It can take over a thousand years for ocean thermal expansion to equilibrate with warmer air temperatures.[10] Even if there were huge reductions in fossil fuel use and CO_2 emissions, oceans would continue to rise for many centuries because of the slow nature of the processes governing sea-level rise.

5 Church, J., White, N., "Sea-level rise From the Late 19th to Early 21st Century", *Surveys in Geophysics*, 32, 4-5, 585-602 (2011).

6 Nerem, R. S., et al., "Climate-Change-Driven Accelerated Sea-Level Rise Detected in the Altimeter Era", *Proceedings of the National Academy of Sciences of the United States of America*, 115(9), 2022-2025 (2018).

7 Griggs, G, et al., "Rising Seas in California: An Update on Sea-Level Rise Science", California Ocean Science Trust (2017). http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

8 Griggs, G, et al., "Rising Seas in California: An Update on Sea-Level Rise Science", *California Ocean Science Trust*, http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

9 Church, J. A., et al., Chap. 13: "Sea Level Change", *Climate Change 2013: The Physical Science Basis* (2013).

10 Levermann, A., et al., "The Multimillennial Sea-Level Commitment of Global Warming", *Proceedings of the National Academy of Sciences*, 110(34), 13745-13750 (2013).

Climate Models and Sea-Level Rise Prediction

Representative Concentration Pathways (RCPs) are future climate scenarios that describe four alternative trajectories of CO_2 emissions and the resulting atmospheric CO_2 concentrations between the years 2000-2100 (RCP2.6, RCP4.5, RCP6.0, and RCP8.5). These scenarios cover a range of possible climate policy outcomes based on different assumptions about energy consumption, energy sources, land use change, economic growth, and population. This limited set of scenarios ensures that researchers around the world, especially climate modelers, can conduct research that is comparable. The scenarios range from RCP2.6, the most aggressive in reducing carbon emissions, to RCP8.5, considered a "business as usual" scenario in which no effort is taken to reduce emissions.[11,12]

This study looks at projected sea-level rise under RCP2.6 and RCP4.5 combined with an annual, one-year storm event. We chose the two most conservative (most proactive) future scenarios in order to avoid worst-case assessments and focus the discussion on the baseline costs that will be required to protect our coastal communities against unavoidable, short-term sea-level rise. Under RCP2.6, the Intergovernmental Panel on Climate Change's Fifth Assessment Report projects that global mean sea level will likely rise 11–24 inches by 2100.[13,14] Under RCP4.5, global mean sea level is projected to likely rise 14–28 inches by 2100.[15,16] For RCP6.0 and RCP8.5, which are more plausible paths based on current policies, global mean sea level is projected to likely rise 15–29 inches and 20–39 inches, respectively, by 2100. Projections of sea-level rise that rely on these RCP scenarios generally provide conservative estimates because they do not account for the possibility that changing Antarctic ice sheet dynamics could dramatically increase sea levels by the end of the century.[17,18]

11 Jones, C., et al., "Twenty-First-Century Compatible CO_2 Emissions and Airborne Fraction Simulated by CMIP5 Earth System Models Under Four Representative Concentration Pathways", *Journal of Climate*, 26, 4398-4413 (2013).

12 Collins, M., et al., Chap. 12: "Long-term Climate Change: Projections, Commitments and Irreversibility", *Climate Change 2013: The Physical Science Basis* (2013).

13 At least about 66% probability, according to Church, J. A., et al., Chap. 13: "Sea Level Change", *Climate Change 2013: The Physical Science Basis* (2013).

14 Relative to global mean sea level over 1986–2005.

15 At least about 66% probability, according to Church, J. A., et al., Chap. 13: "Sea Level Change", *Climate Change 2013: The Physical Science Basis* (2013).

16 Church, J. A., et al., Chap. 13: "Sea Level Change", *Climate Change 2013: The Physical Science Basis* (2013).

17 DeConto, R. & Pollard, D., "Contribution of Antarctica to Past and Future Sea-Level Rise", *Nature*, 531(7596): 591-597 (2016).

18 Shepherd, A., et al., "Mass Balance of the Antarctic Ice Sheet From 1992 to 2017, *Nature*, 556, 219-222 (2018).

The sea-level rise projections listed above are global means and do not account for regional differences, which can vary greatly. For example, the NOAA tide station in Chesapeake Bay indicates that local sea level is increasing at a rate of 5.92 mm per year, faster than nearly anywhere else in the United States. Conversely, sea-level in Crescent City, CA is *falling* at a rate of 0.78 mm per year due to local tectonic activity.[19,20] The future rate of sea-level rise is projected to be greater than the global average for the Northeast Atlantic (Virginia coast and northward) and the Western Gulf of Mexico coasts (Texas and Louisiana).[21] The effects of sea-level rise are already impacting some coastal communities: at many tide stations in the United States, the frequency of high-tide flooding has increased by an order of magnitude over the past few decades, moving from a rare event (once every 3 to 5 years) to a disruptive problem (once every 3 months).[22]

A *1-year storm surge* is the level to which coastal water rises in any given year during a typical storm according to historical sea-level data. It is an extremely common storm event, as opposed to a *100-year storm surge*, which represents a severe event that statistically occurs once every 100 years. This study relied on geographically specific storm surge predications based on work by Tebaldi et al. (2012) and Buchanan et al. (2016).

Methods

The methods employed by Resilient Analytics to assess the potential cost of protecting the coastline from the impacts of sea-level rise and 1-year storm surge entailed a multi-step process incorporating climate projections, processing detailed coastline flooding maps, a computational assessment of where tidal shorelines needed protection, and a calculation of the costs associated with this protection. The process developed for this estimation is based on previous climate impact work developed by Resilient Analytics and other scholars for

19 NOAA Center for Operational Oceanographic Products and Services, "U.S. Linear Relative Sea Level Trends," 2018, retrieved from https://tidesandcurrents.noaa.gov/sltrends/mslUSTrendsTable.html

20 Griggs, G, et al., "Rising Seas in California: An Update on Sea-Level Rise Science", *California Ocean Science Trust* (2017). http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

21 Sweet, W., et al., "Global and Regional Sea Level Rise Scenarios for the United States," NOAA Technical Report NOS CO-OPS 083 (2017).

22 Sweet, W., et al., "Sea Level Rise and Nuisance Flood Frequency Changes Around the United States," NOAA Technical Report NOS CO-OPS 073 (2014).

infrastructure impacts locally, regionally, and globally.[23,24,25]

Sea-Level Rise Projections

Climate Central, a non-profit climate science and research organization, headquartered in Princeton, New Jersey, provided the research team with high-resolution maps for the contiguous United States coast based on published sea-level rise projections.[26] The maps provided projection data for all areas that will be impacted by sea-level rise as well as sea-level rise coupled with 1-year storm surge events. The maps include detailed analysis of the coastline down to a 5-meter x 5-meter grid to ensure accurate capture of tidal inlets. Each grid location indicated whether it was projected to be flooded and to what depth that flooding was expected to reach.

Future sea-level rise is dependent on the concentration of greenhouse gases in the atmosphere, so two RCPs were used to evaluate potential future scenarios. Specifically, the RCP2.6 and RCP4.5 pathways were used to capture a low-range and mid-range estimate of projected sea-level rise impacts. A suite of climate models, known as the CMIP5 GCM, were used to predict future sea-level rise. From this set of projections, the 5th, 50th, and 95th percentile results were selected for further analysis in this study. Three time periods were selected from the results for the impact analysis: 2040, 2060, and 2100. These data sets were provided with and without 1-year storm surge projections to capture both the base sea-level rise impact and the potential for regular flood impacts. These combinations resulted in a total of 36 different scenarios that were considered throughout the duration of the study.

Defining Infrastructure

In order to understand the impact that the projected flooding would have on public infrastructure, it was necessary to determine the location of infrastructure in the impacted

23 Cervigni, Raffaello, A. M. Losos, Paul Chinowsky, and J. L. Neumann. "Enhancing the Climate Resilience of Africa's Infrastructure: The Roads and Bridges Sector." *Publication* 110137 (2016): 1-0.

24 Chinowsky, Paul, Jacob Helman, Sahil Gulati, James Neumann, and Jeremy Martinich. "Impacts of climate change on operation of the US rail network." *Transport Policy* (2017).

25 Schweikert, Amy, Xavier Espinet, and Paul Chinowsky. "The triple bottom line: bringing a sustainability framework to prioritize climate change investments for infrastructure planning." *Sustainability Science* 13, no. 2 (2018): 377-391.

26 Kopp, R., et al., "Evolving understanding of Antarctic ice-sheet physics and ambiguity in probabilistic sea-level projections." *Earth's Future* 5, no. 12 (2017): 1217-1233.

areas. Analysts at Climate Central provided this study with GIS files of the public infrastructure locations, based on previous work and public database information.[27] The infrastructure identification process emphasized public infrastructure including schools, hospitals, medical facilities, government buildings, airports, and all public horizontal infrastructure (roads, railways, and runways). Although the study does not consider private residences directly, the location of most residential areas can be determined through the location of roads that are used to access residential areas. By considering all areas that contain a road (both paved and unpaved), the majority of residential areas were also considered. Areas that do not have any public infrastructure, such as national parks or protected wildlife areas, were not included in the study as pieces of infrastructure and were therefore not considered for protection.

The sea-level rise impacts and infrastructure locations were merged into one data set, and the results were placed into a gridded map (each grid square was 150 m^2).

Determining Where to Place Seawalls

The next step of the process was determining what areas of coastline needed protection from flooding. This determination requires a series of logic tests performed by a computer model to understand if a flooded grid is directly impacted by flooding from adjacent waterways, or if it is indirectly affected by other grids that are adjacent to waterways.

The first logic question determined if any given gridded square is located within an area that is expected to flood, according to a specific climate scenario. This question is nuanced in that there must be a determination as to how much of a grid cell needs to be flooded for it to be considered a flooded grid. For the purposes of this study, grid squares are considered flooded if 15% or more of the land area within that grid is inundated. This 15% limit assisted in eliminating overprotection scenarios and was chosen based on engineering judgement upon inspection of protection patterns using 5%, 10%, 15% and 20%.

Next, the model determines whether a grid is flooded due to direct flooding or indirect flooding. Direct flooding occurs when a grid is adjacent to a waterway and the scenario indicates that the grid is flooded due to an overtopping of that adjacent waterway. In these cases, the adjacent shoreline needs to be protected to prevent the grids from incurring flooding. The indirect case

27 Strauss, B., et al., Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States, *Environmental Research Letters*, 7, 021001.

occurs when an inland grid is flooded due to being connected to a water-facing grid. In this case, the model must trace the path of the flood back to its origin, which is the grid adjacent to the coastline. The model then protects the coastline adjacent grid to eliminate the threat to the overall flood area.

In the next logic test, the model determined what portion of the identified flood area needs to be protected based on the presence of infrastructure. This eliminates the need for protection in areas such as nature preserves or remote areas that are uninhabited.

In the final logic test, the model calculates the length of coastline to be protected. This study utilizes the NOAA Medium Resolution Shoreline Data in order to determine what is considered shoreline. The model analyzed the coastline for every grid that was determined to require protection from flooding. For each of the identified grids, the length of coastline in that grid was calculated to the linear foot.

Seawall Cost Estimates

The estimated costs of seawall construction were created using a combination of nationally recognized construction cost estimates from the engineering community and local estimates from seawall design and construction companies to establish realistic localized per-foot costs. The location factor was important to ensure that costs reflected the rates at a local level since these rates can vary by over 10% depending on location.

The cost estimates are divided into two categories: coastal seawalls and inland seawalls. Coastal seawalls have been used to protect wave-impacted coastlines to stop or reduce the impacts of flooding. In this study, coastal seawalls are defined as retaining walls that are either adjacent to shore structures or serve as standalone offshore structures. This design is utilized wherever the coast is directly exposed to open water. Inland seawalls, often referred to as *bulkheads*, are used to protect property against rising inland water levels and indirect wave action.

Once the model determines whether a coastal or inland design is appropriate for the given grid location, the cost of that solution is multiplied by the linear feet of protection required to obtain a total cost. The results are presented as total cost and per capita cost, calculated using population estimates from the US Census Bureau's American Community Survey 5-year estimates.

Results

The data we report are from model run RCP4.5, the year 2040, with a 1-year storm surge, for the 50th percentile, unless otherwise specified.

The model predicts that by the year 2040 (2100), the contiguous US will need to construct 50,145 miles of seawall (60,213 miles), at a cost of $416 billion ($518 billion) to protect public infrastructure from predicted sea-level rise impacts (Table 1). Florida incurs the greatest state cost, facing over $75 billion in seawall defenses alone by 2040 (Table 1).

These results are planning-level estimates only and should not take the place of a detailed engineering analysis.

Table 1: States Facing Costs to Protect Against Sea-Level Rise

Costs and seawall length by state for RCP4.5, with a 1-year storm surge, in 2040 and 2100.

2040				2100				
Cost Ranking	State	Cost (USD)	Seawall Length (miles)	Cost Ranking	State	Cost (USD)	Seawall Length (miles)	% Cost Increase
17	AL	$5,997,821,000	599	17	AL	$7,648,923,000	741	28%
8	CA	$21,999,799,000	1,785	8	CA	$27,339,843,000	2,243	24%
18	CT	$5,339,664,000	394	18	CT	$6,672,956,000	500	25%
23	DC	$138,316,000	21	23	DC	$197,817,000	30	43%
15	DE	$9,415,208,000	941	15	DE	$10,123,742,000	1,002	8%
1	FL	$75,898,048,000	9,243	1	FL	$109,397,491,000	12,765	44%
13	GA	$15,060,564,000	2,460	13	GA	$15,773,720,000	2,522	5%
2	LA	$38,431,868,000	6,764	2	LA	$42,258,710,000	7,404	10%
11	MA	$18,731,965,000	1,291	10	MA	$24,000,218,000	1,594	28%
5	MD	$27,414,762,000	2,996	5	MD	$36,033,205,000	3,828	31%
14	ME	$10,897,440,000	1,267	14	ME	$13,761,299,000	1,566	26%
19	MS	$3,273,800,000	401	19	MS	$4,369,649,000	494	34%
3	NC	$34,838,128,000	5,250	4	NC	$36,722,499,000	5,404	5%

[Table 1, continued]

2040				2100				
Cost Ranking	State	Cost (USD)	Seawall Length (miles)	Cost Ranking	State	Cost (USD)	Seawall Length (miles)	% Cost Increase
21	NH	$1,032,541,000	122	21	NH	$1,197,839,000	141	16%
6	NJ	$24,985,408,000	2,696	6	NJ	$29,315,494,000	3,009	17%
12	NY	$17,388,527,000	1,262	11	NY	$23,959,435,000	1,724	38%
16	OR	$7,550,580,000	687	16	OR	$9,731,336,000	873	29%
22	PA	$482,927,000	66	22	PA	$950,117,000	130	97%
20	RI	$2,872,550,000	247	20	RI	$3,935,942,000	344	37%
9	SC	$20,061,030,000	3,202	12	SC	$22,321,331,000	3,378	11%
10	TX	$19,279,011,000	2,738	9	TX	$26,578,972,000	3,631	38%
4	VA	$31,207,175,000	4,063	3	VA	$37,714,317,000	4,928	21%
7	WA	$23,892,865,000	1,651	7	WA	$28,196,185,000	1,963	18%
	TOTAL	**$416,189,998,000**	**50,145**		TOTAL	**$518,201,041,000**	**60,213**	

Table 2: Counties Facing Costs Greater Than $1 Billion

This study identifies 132 counties that will face costs greater than $1 billion (Table 2).

Ranking	County	State	Cost (USD)
1	Suffolk County	NY	$11,373,203,000
2	Monroe County	FL	$11,087,377,000
3	Barnstable County	MA	$7,039,036,000
4	Dorchester County	MD	$6,531,735,000
5	Charleston County	SC	$6,319,023,000
6	Beaufort County	SC	$6,127,015,000
7	Cumberland County	NJ	$5,789,911,000
8	Cameron Parish	LA	$5,527,708,000
9	Dare County	NC	$5,479,912,000
10	Accomack County	VA	$4,913,390,000
11	Terrebonne Parish	LA	$4,731,861,000

[Table 2, continued]

Ranking	County	State	Cost (USD)
12	Ocean County	NJ	$4,601,543,000
13	St. Mary Parish	LA	$4,547,520,000
14	Cape May County	NJ	$4,246,506,000
15	Chatham County	GA	$4,200,013,000
16	Plaquemines Parish	LA	$4,006,559,000
17	Carteret County	NC	$3,980,168,000
18	Taylor County	FL	$3,969,756,000
19	Sussex County	DE	$3,960,716,000
20	Galveston County	TX	$3,902,091,000
21	Collier County	FL	$3,847,124,000
22	Franklin County	FL	$3,794,895,000
23	Lee County	FL	$3,530,371,000
24	Duval County	FL	$3,519,456,000
25	Lafourche Parish	LA	$3,291,630,000
26	Hyde County	NC	$3,275,386,000
27	Salem County	NJ	$3,254,307,000
28	Grays Harbor County	WA	$3,252,516,000
29	Miami-Dade County	FL	$3,187,877,000
30	Somerset County	MD	$3,103,594,000
31	Mobile County	AL	$3,023,233,000
32	Pinellas County	FL	$3,001,555,000
33	Baldwin County	AL	$2,974,587,000
34	Camden County	GA	$2,951,842,000
35	Glynn County	GA	$2,944,328,000
36	Matagorda County	TX	$2,842,992,000
37	Beaufort County	NC	$2,807,684,000
38	Clallam County	WA	$2,804,153,000
39	Kent County	DE	$2,803,336,000
40	Georgetown County	SC	$2,779,912,000
41	Vermilion Parish	LA	$2,752,922,000
42	Levy County	FL	$2,735,896,000

[Table 2, continued]

Ranking	County	State	Cost (USD)
43	Plymouth County	MA	$2,733,209,000
44	Hillsborough County	FL	$2,701,224,000
45	Worcester County	MD	$2,677,970,000
46	Brunswick County	NC	$2,665,667,000
47	Onslow County	NC	$2,660,449,000
48	Solano County	CA	$2,651,660,000
49	New Castle County	DE	$2,651,156,000
50	St. Mary's County	MD	$2,580,370,000
51	Pamlico County	NC	$2,547,038,000
52	Humboldt County	CA	$2,543,754,000
53	Dixie County	FL	$2,527,310,000
54	Essex County	MA	$2,478,393,000
55	Brazoria County	TX	$2,436,894,000
56	Pacific County	WA	$2,421,406,000
57	McIntosh County	GA	$2,384,361,000
58	Talbot County	MD	$2,376,301,000
59	Mendocino County	CA	$2,304,753,000
60	Northumberland County	VA	$2,282,367,000
61	Jefferson County	TX	$2,226,575,000
62	Currituck County	NC	$2,225,353,000
63	Skagit County	WA	$2,198,549,000
64	Mathews County	VA	$2,169,506,000
65	Volusia County	FL	$2,164,314,000
66	Dukes County	MA	$2,161,128,000
67	San Juan County	WA	$2,145,603,000
68	Wakulla County	FL	$2,138,965,000
69	Gloucester County	VA	$2,131,285,000
70	Atlantic County	NJ	$2,126,117,000
71	Citrus County	FL	$2,114,361,000
72	Island County	WA	$2,085,436,000
73	Manatee County	FL	$2,022,544,000

[Table 2, continued]

Ranking	County	State	Cost (USD)
74	Brevard County	FL	$2,016,984,000
75	Santa Barbara County	CA	$2,007,493,000
76	Jefferson County	WA	$1,988,324,000
77	St. Johns County	FL	$1,976,528,000
78	Lancaster County	VA	$1,910,896,000
79	Pasco County	FL	$1,902,080,000
80	Nassau County	NY	$1,898,430,000
81	Hancock County	ME	$1,897,524,000
82	Anne Arundel County	MD	$1,885,389,000
83	Washington County	RI	$1,877,044,000
84	Gulf County	FL	$1,822,844,000
85	Queen Anne's County	MD	$1,817,082,000
86	Jackson County	MS	$1,790,400,000
87	Bristol County	MA	$1,771,597,000
88	Craven County	NC	$1,728,854,000
89	Northampton County	VA	$1,722,736,000
90	York County	ME	$1,720,259,000
91	Virginia Beach city	VA	$1,716,510,000
92	Calcasieu Parish	LA	$1,706,849,000
93	Lincoln County	OR	$1,702,086,000
94	Washington County	ME	$1,696,260,000
95	New Haven County	CT	$1,676,482,000
96	Charlotte County	FL	$1,648,130,000
97	Liberty County	GA	$1,618,356,000
98	Bay County	FL	$1,592,755,000
99	Clatsop County	OR	$1,583,660,000
100	New Hanover County	NC	$1,577,112,000
101	St. Tammany Parish	LA	$1,569,754,000
102	Chambers County	TX	$1,566,687,000
103	New London County	CT	$1,540,954,000
104	Kent County	MD	$1,538,213,000

[Table 2, continued]

Ranking	County	State	Cost (USD)
105	Jefferson Parish	LA	$1,492,583,000
106	Nantucket County	MA	$1,489,874,000
107	Fairfield County	CT	$1,426,282,000
108	Monmouth County	NJ	$1,405,033,000
109	Berkeley County	SC	$1,377,966,000
110	Iberia Parish	LA	$1,369,525,000
111	Cumberland County	ME	$1,368,080,000
112	Sonoma County	CA	$1,361,121,000
113	Whatcom County	WA	$1,332,840,000
114	Sagadahoc County	ME	$1,315,125,000
115	Middlesex County	VA	$1,303,959,000
116	Jasper County	SC	$1,282,418,000
117	Tillamook County	OR	$1,272,835,000
118	Wicomico County	MD	$1,266,722,000
119	King County	WA	$1,257,733,000
120	St. Bernard Parish	LA	$1,245,843,000
121	Knox County	ME	$1,230,140,000
122	Westmoreland County	VA	$1,194,001,000
123	Sarasota County	FL	$1,155,486,000
124	Charles County	MD	$1,151,405,000
125	Lincoln County	ME	$1,144,820,000
126	Marin County	CA	$1,136,640,000
127	St. Martin Parish	LA	$1,125,893,000
128	Colleton County	SC	$1,114,143,000
129	Snohomish County	WA	$1,112,754,000
130	San Joaquin County	CA	$1,027,678,000
131	Nassau County	FL	$1,002,791,000
132	Kitsap County	WA	$1,001,277,000

Table 3: Communities Facing Costs Greater Than $1 Billion

This study identifies seven communities that will face costs greater than $1 billion (Table 3). Note that "communities" includes self-governing cities, towns, and villages, as well as their unincorporated counterparts, known as Census Designated Places.

Ranking	City	State	Cost (USD)
1	Jacksonville	FL	$3,460,516,000
2	New York	NY	$1,973,735,000
3	Virginia Beach	VA	$1,716,510,000
4	Marathon	FL	$1,506,927,000
5	Fire Island	NY	$1,449,948,000
6	Galveston	TX	$1,057,849,000
7	Charleston	SC	$1,031,923,000

Table 4: Communities Facing Per Capita Costs Greater Than $500,000

This study identifies 43 communities that will face per capita costs greater than $500,000 (Table 4).

Ranking	City	State	Cost per Capita (USD)
1	Junction City	WA	$7,155,000
2	Fire Island	NY	$5,894,000
3	Popponesset Island	MA	$3,966,000
4	Dames Quarter	MD	$3,894,000
5	Quintana	TX	$3,439,000
6	Oak Beach-Captree	NY	$3,359,000
7	Pawleys Island	SC	$3,211,000
8	Frenchtown-Rumbly	MD	$2,651,000
9	Pine Island	FL	$2,546,000
10	Marineland	FL	$2,249,000
11	Hat Island	WA	$2,102,000
12	Gilgo	NY	$1,992,000
13	Ocracoke	NC	$1,753,000
14	Moss Landing	CA	$1,552,000
15	Fairmount	MD	$1,461,000
16	West Hampton Dunes	NY	$1,362,000
17	Napeague	NY	$1,281,000
18	Saltaire	NY	$1,241,000
19	Bald Head Island	NC	$1,092,000
20	Dering Harbor	NY	$973,000
21	Fishers Island	NY	$972,000
22	Elliott	MD	$969,000
23	Sanford	VA	$950,000
24	Hobucken	NC	$948,000
25	St. George Island	FL	$912,000
26	Seconsett Island	MA	$901,000
27	Cameron	LA	$870,000

[Table 4, continued]

Ranking	City	State	Cost per Capita (USD)
28	Bayport	FL	$820,000
29	North Key Largo	FL	$819,000
30	Topsail Beach	NC	$739,000
31	North Topsail Beach	NC	$682,000
32	Deal Island	MD	$664,000
33	Asharoken	NY	$653,000
34	Aripeka	FL	$621,000
35	Altoona	WA	$613,000
36	Taylors Island	MD	$609,000
37	Gwynn	VA	$583,000
38	Sekiu	WA	$573,000
39	Strathmere	NJ	$544,000
40	Dauphin Island	AL	$543,000
41	Fenwick	CT	$538,000
42	Horseshoe Beach	FL	$519,000
43	Slaughter Beach	DE	$507,000

Table 5: Congressional District Cost Rankings

This study identifies 137 congressional districts that will incur costs to protect their shoreline against sea-level rise by 2040 (Table 5).

Ranking	Congressional District		Cost (USD)
1	NC	3	$28,184,617,000
2	MD	1	$20,492,822,000
3	FL	2	$19,013,483,000
4	NJ	2	$18,124,997,000
5	LA	3	$17,498,287,000
6	VA	1	$15,472,328,000
7	LA	1	$15,394,584,000
8	GA	1	$15,060,564,000
9	MA	9	$13,857,355,000
10	FL	26	$12,906,485,000
11	SC	1	$11,298,192,000
12	VA	2	$11,195,012,000
13	WA	6	$10,037,982,000
14	DE	(at Large)	$9,415,208,000
15	NY	1	$9,059,599,000
16	TX	14	$8,639,534,000
17	WA	2	$7,456,997,000
18	CA	2	$7,303,127,000
19	ME	1	$6,803,346,000
20	TX	27	$6,105,658,000
21	AL	1	$5,997,821,000
22	FL	19	$5,789,968,000
23	FL	4	$5,647,118,000
24	SC	6	$5,008,135,000
25	MD	5	$4,925,217,000
26	NC	7	$4,910,089,000

[Table 5, continued]

Ranking	Congressional District		Cost (USD)
27	ME	2	$4,094,094,000
28	FL	6	$3,923,020,000
29	LA	6	$3,846,989,000
30	SC	7	$3,754,703,000
31	FL	16	$3,527,392,000
32	MS	4	$3,273,800,000
33	CA	3	$3,113,328,000
34	WA	3	$3,075,147,000
35	FL	11	$3,030,741,000
36	FL	1	$3,028,569,000
37	OR	5	$2,974,921,000
38	TX	36	$2,952,301,000
39	CA	24	$2,816,183,000
40	FL	17	$2,795,206,000
41	FL	12	$2,721,312,000
42	CT	2	$2,562,678,000
43	MA	6	$2,465,678,000
44	FL	8	$2,438,881,000
45	NJ	3	$2,435,729,000
46	OR	4	$2,286,648,000
47	OR	1	$2,199,679,000
48	FL	13	$2,182,323,000
49	VA	3	$2,145,779,000
50	RI	2	$2,030,097,000
51	VA	4	$1,900,473,000
52	NY	2	$1,809,784,000
53	FL	18	$1,797,435,000
54	NC	1	$1,743,421,000
55	LA	2	$1,643,332,000
56	CT	3	$1,587,843,000

[Table 5, continued]

Ranking	Congressional District		Cost (USD)
57	NJ	6	$1,573,643,000
58	TX	34	$1,530,128,000
59	FL	14	$1,519,734,000
60	NY	3	$1,485,736,000
61	CA	9	$1,453,100,000
62	MA	8	$1,393,685,000
63	FL	25	$1,386,518,000
64	WA	1	$1,257,506,000
65	CT	4	$1,189,142,000
66	CA	5	$1,172,505,000
67	FL	27	$1,141,970,000
68	FL	3	$1,110,929,000
69	WA	7	$1,107,054,000
70	NJ	1	$1,036,855,000
71	NH	1	$1,032,541,000
72	CA	20	$907,494,000
73	NY	4	$893,421,000
74	MD	3	$869,978,000
75	RI	1	$842,452,000
76	MD	2	$840,701,000
77	NY	19	$837,610,000
78	CA	18	$737,899,000
79	CA	48	$701,102,000
80	NJ	9	$630,289,000
81	NY	11	$622,736,000
82	FL	23	$620,478,000
83	CA	14	$598,176,000
84	NJ	4	$553,596,000
85	WA	9	$536,379,000
86	NY	5	$519,670,000

[Table 5, continued]

Ranking	Congressional District		Cost (USD)
87	NY	16	$471,008,000
88	CA	52	$470,027,000
89	CA	17	$460,578,000
90	FL	22	$458,383,000
91	MA	4	$454,989,000
92	NY	17	$453,181,000
93	WA	10	$421,801,000
94	CA	11	$404,389,000
95	NJ	8	$377,707,000
96	FL	5	$347,346,000
97	MA	5	$332,183,000
98	CA	49	$327,095,000
99	CA	26	$286,586,000
100	MD	4	$283,163,000
101	NY	18	$260,492,000
102	NY	10	$252,661,000
103	CA	51	$251,925,000
104	VA	11	$249,931,000
105	NY	8	$249,638,000
106	CA	47	$246,333,000
107	VA	8	$240,101,000
108	CA	12	$221,175,000
109	CA	13	$217,938,000
110	MA	7	$215,361,000
111	FL	21	$186,252,000
112	NY	14	$176,637,000
113	FL	7	$163,742,000
114	CA	44	$151,831,000
115	NJ	10	$149,753,000
116	DC	(at Large)	$138,316,000

[Table 5, continued]

Ranking	Congressional District		Cost (USD)
117	CA	33	$125,360,000
118	NY	20	$125,228,000
119	FL	24	$109,899,000
120	NJ	12	$100,024,000
121	OR	3	$89,333,000
122	NY	12	$74,933,000
123	LA	5	$48,676,000
124	TX	29	$46,857,000
125	NY	7	$37,864,000
126	CA	15	$33,649,000
127	NY	15	$29,186,000
128	FL	20	$28,010,000
129	NY	13	$26,275,000
130	FL	15	$22,855,000
131	MA	3	$12,715,000
132	VA	7	$3,551,000
133	MD	7	$2,881,000
134	NY	9	$2,869,000
135	NJ	5	$2,815,000
136	TX	18	$2,301,000
137	TX	22	$2,233,000

Discussion

These cost estimates represent a small fraction of total costs associated with protecting our coastal communities against sea-level rise. First, this study only considers relatively conservative estimates of future sea-level rise. Second, it does *not* account for many line items that must be included in city resilience plans. For example, in New York City's comprehensive plan to defend the city against predicted sea-level rise, coastal protection amounts to only 16-20% of the total estimated cost. Other resilience considerations include: elevating buildings, insurance, utilities, liquid fuels, healthcare and community preparedness, telecommunications, transportation, environmental protection and remediation, and water and wastewater.[28]

Furthermore, this study only takes into account a 1-year storm surge. Experts recommend that communities prepare for more than 6.5 ft of sea-level rise by 2100.[29] Hurricane Sandy was statistically between a 103 – 260-year storm. Sandy pummeled New York's coastal communities with a 13 ft storm surge. Mounting evidence indicates that Sandy-sized storms will become more prevalent as climate change worsens.[30,31,32]

This study does not attempt to answer any questions that could be considered policy decisions. Some regions will be able to reduce their protective costs in exchange for relinquishing some land to the sea. In areas where the costs to protect their communities are greater than the cost to relocate, community members may be forced to consider managed retreat. This study identified many small communities where the costs of protection exceed $100,000 per person, and hundreds where the costs of protection exceed $10,000 per person. Managed retreat may become an option in these locations but is controversial due to the social and psychological difficulties associated with removing people from their homes. Additional research is needed to understand the conditions under which managed retreat should be implemented.

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