Draft

Coastal Hazard Adaptation Plan, City of Oceanside

Prepared for
City of Oceanside

June 2019

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EXECUTIVE SUMMARY

Future sea-level rise is expected to create a permanent rise in ocean water levels that would shift the water's edge landward. If no action is taken, higher water levels would increase erosion of the beaches, cause a loss of sand, and result in a narrower beach. Additionally, the combination of higher ocean water levels and beach erosion would result in greater flooding and damage during coastal storms. This document, the City of Oceanside Coastal Hazard Adaptation Plan, identifies a variety of adaptation strategies to help the Oceanside community plan for and address future sea-level rise, storm surge, coastal flooding, and erosion. It provides a framework for the City of Oceanside to monitor effects of coastal erosion and flooding with sea-level rise and prepare for identified vulnerabilities by choosing from a toolbox of adaptation strategies. This Coastal Hazard Adaptation Plan provides flexibility so that appropriate adaptation strategies can be chosen over time as specified triggers for action are reached. This Coastal Hazard Adaptation Plan identifies the lead times necessary to put policies and programs into place, and implement project-level planning and approvals so that the City of Oceanside can begin planning for adaptation in advance of when implementation is needed.

In 2018, Environmental Science Associates (ESA) performed a Coastal Hazards Vulnerability Assessment to describe existing conditions and future vulnerability of the City of Oceanside's coastal assets and resources to projected sea-level rise, coastal flooding, and erosion. The assessment is documented in the Coastal Hazard Vulnerability Assessment, City of Oceanside (ESA 2018). The findings of that assessment have informed the identification of the adaptation strategies included in this Coastal Hazard Adaptation Plan. The Vulnerability Assessment and this Coastal Hazard Adaptation Plan will guide the development of new policy language addressing sea-level rise for incorporation into the City of Oceanside's Local Coastal Program. The Local Coastal Program is a planning document that regulates development in the City of Oceanside's coastal zone and establishes a long-range vision for the community.

This Coastal Hazard Adaptation Plan addresses the following vulnerabilities in Oceanside:

- Coastal flooding and beach erosion
- River and creek flooding

- Oceanside Small Craft Harbor and Oceanside Pier flooding

Adaptation Planning Framework

This Coastal Hazard Adaptation Plan provides a framework for the City of Oceanside to monitor the effects of coastal erosion and flooding with sea-level rise and to prepare for identified vulnerabilities by choosing from a toolbox of adaptation strategies. Adaptation should be flexible or adaptive as strategies are tested, sea-level rise science advances, and actual monitored conditions change. Strategies should also reflect the Oceanside community's risk tolerance, local conditions, and guiding principles. Project-level planning and approvals will be required to further refine and implement the adaptation strategies included in this Coastal Hazard Adaptation Plan. Lead times for project-level planning are identified so that the City of Oceanside can begin planning for adaptation in advance of when implementation is needed.

In accordance with California Coastal Commission (CCC) Sea-Level Rise Policy Guidance (CCC 2018), the Oceanside Coastal Hazard Adaptation Plan:

- Is based on the best science and adaptation practices available today;
- Acknowledges that sea-level rise science and practices are evolving and that the City of Oceanside will evaluate future decisions and take action based on the best-available science and technology at the time; and
- Includes a range of sea-level rise adaptation strategies within the three general categories of adaptation: protect, accommodate, and retreat.

The Oceanside Guiding Principles were developed to evaluate adaptation strategies to address the projected impacts of sea-level rise and related hazards:

1. Preserve and enhance the following features and activities:
   - Beach and ocean
   - Public amenities
   - Scenic resources
   - Natural habitat
   - Commercial goods and services
   - Arts and entertainment
   - Community events
   - Public parking
2. When evaluating adaptation options, the following should be considered:
   - Coastal access

- Public safety
- Visual quality/community character
- Natural resources
- Private property rights
- Economic development
- Fiscal health
- Legal exposure/indemnity
- Flexibility

3. Minimize the impacts of sea-level rise and related hazards by
   - Using science to guide decisions, with considerations for
     - local conditions,
     - scenario planning, and
     - a precautionary approach;
   - Minimizing vulnerabilities through planning and development standards that consider
     - new development,
     - social and economic needs of the community, and
     - an assumption of risk.
4. Consider and prioritize the following resources in our assessment of adaptation options:
   - Maximize protection of public access, recreation, and sensitive resources by preserving
     - natural shoreline values and processes,
     - public trust lands, and
     - mitigating unavoidable impacts;
   - Maximize
     - coordination with regional, state, and federal agencies,
     - participate in regional vulnerability assessment and planning, and
     - foster public participation.

Consistent with California Coastal Commission Sea-Level Rise Policy guidance, this Coastal Hazard Adaptation Plan includes a variety of adaptation strategies, including traditional coastal engineering and nature-based infrastructure solutions. In choosing appropriate adaptation strategies, the City of Oceanside will consider multi-objective measures and a holistic approach, rather than focusing on independent or single-purpose solutions to protection. Given the

uncertainty in sea-level rise projections and erosion/flooding model limitations, planning for sea-level rise requires a phased approach. Certain adaptation strategies will be used in the near-term, while others will be needed in the long-term. This phased approach provides a way to manage the inherent uncertainty in timing and extent of potential sea-level rise impacts.

City of Oceanside's Potential Adaptation Strategies

This Coastal Hazard Adaptation Plan presents a suite of adaptation strategies for each of the identified vulnerabilities.

Coastal Flooding and Beach Erosion

Oceanside's extensive development and recreational amenities along the beach front are currently vulnerable to tidal inundation, coastal storm flooding, wave impact, and beach erosion. The City of Oceanside has already implemented several adaptation strategies to reduce the risk of flooding and beach erosion, including beach nourishment and sand bypassing, the Oceanside Small Craft Harbor breakwater, and sea walls and revetments along the coast. Other adaptation strategies for coastal flooding and beach erosion include: coastal sediment management, sand retention structures, shoreline protection devices, elevation of structures and/or property grades, and managed retreat.
Table ES-1 summarizes the cost, environmental impact, flood protection, and timeline to implement each of the adaptation strategies presented in this Adaptation Plan for the low-lying waterfront and beach areas.

Table ES-1. Beach and Coastal Flooding Adaptation Strategies Summary

Adaptation Strategy	Cost	Environmental Impact	Flood Protection	Timeline to Implement
Coastal Sediment Management	$$	Minor	Short-term	
Sand Retention Structures	$$	Major	Short-term	
Shoreline Protection Devices	$$	Major	Short-term	
Elevation of Structures and/or Property Grades	$$$	Benefit	Mid-term	
Managed Retreat	$$$$	Benefit	Long-term	

River and Creek Flooding

Oceanside's extensive development along the rivers and creeks is currently vulnerable to riverine storm flooding. The City of Oceanside has already implemented or is in the process of developing several adaptation strategies to reduce the risk of flooding, including U.S. Army Corps of Engineers dredging along the San Luis Rey River, the Buena Vista Lagoon Enhancement project, flood detention basins along Loma Alta Creek, levees along the San Luis Rey

River, and removal of the La Salina Wastewater Treatment Plant. Other adaptation strategies for river and creek flooding include: river and creek channel management, groundwater pumping, flood detention basins, river and creek flood walls or levees with wetland restoration, elevation of structures and/or property grades, and managed retreat. **Table ES-2** summarizes the cost, environmental impact, flood protection, and timeline to implement each of the adaptation strategies for the low-lying areas along the rivers and creeks.

Table ES-2. River and Creek Adaptation Strategies Summary

Adaptation Strategy	Cost	Environmental Impact	Flood Protection	Timeline to Implement
Channel Dredging	$$	Major	Mid-term	
Mouth Maintenance	$$	Minor	Mid-term	
Groundwater Pumping	$$$	Minor	Long-term	
Flood Detention Basins	$$	Major	Long-term	
Levees with Wetlands Restoration	$$$	Major	Mid-term	
Elevation of Structures and/or Property Grades	$$$	Benefit	Mid-term	
Managed Retreat	$$$$	Benefit	Long-term	

Oceanside Small Craft Harbor and Oceanside Pier Flooding

Oceanside's extensive development in the Oceanside Small Craft Harbor and on the Oceanside Pier is currently vulnerable to tidal inundation, coastal storm flooding, and wave impact. The City of Oceanside has already implemented the Oceanside Small Craft Harbor breakwater as an adaptation strategy to reduce the risk of flooding. Other adaptation strategies include: raising and/or modifying the Oceanside Small Craft Harbor breakwater, raising the marina facilities, raising the Oceanside Pier, managed retreat, abandoning the Oceanside Small Craft Harbor, and Abandoning the Pier. **Table ES-3** summarizes the cost, environmental impact, flood protection, and timeline to implement each of the adaptation strategies for the Oceanside Small Craft Harbor and the Oceanside Pier.

Table ES-3. Harbor and Pier Adaptation Strategies Summary

Adaptation Strategy	Cost	Environmental Impact	Flood Protection	Timeline to Implement
Raising and/or Modifying the Breakwater	$$$	Major	Short-term	
Raising the Marina	$$$	Minor	Mid-term	
Raising the Pier	$$$	Minor	Long-term	
Managed Retreat	$$$$	Benefit	Long-term	
Abandoning the Harbor	$$$$	Benefit	Long-term	
Abandoning the Pier	$$$$	Benefit	Long-term	

Adaptation Scenario

One potential adaptation scenario was developed in coordination with the City of Oceanside. This scenario was quantitatively analyzed to assess the costs and benefits of adaptation in comparison to the "do-nothing" scenario from the Vulnerability Assessment. The intent of the scenario analysis is to better inform the Coastal Hazard Adaptation Plan and City of Oceanside. The adaptation scenario presented in the Coastal Hazard Adaptation Plan is not intended to indicate the City of Oceanside's proposed or preferred approach to adaptation. Actual implementation of adaptation by the City of Oceanside will differ from these scenarios and cannot be prescribed at present; actual adaptation will be dependent on monitoring towards adaptation triggers and future City of Oceanside policy decisions.

The adaptation scenario includes new and upgraded bulkheads, elevation of roads and surrounding areas, and beach nourishment at Harbor Beach adjacent to the Oceanside Small Crafts Harbor. It includes expanding and upgrading shoreline protection devices, raising buildings, and continued beach nourishment along the Strand initially, with eventual removal of the Strand and relocation of utilities. From Wisconsin Avenue to Buena Vista Lagoon, the scenario includes expanding and upgrading shoreline protection devices, raising buildings, and continued beach nourishment. Eventually, a bulkhead would be added along a portion of the homes along Buena Vista Lagoon.

The economic analysis shows that the costly investments to adaptation begin to pay off as the overall benefits of adaptation begin to outweigh those of the baseline (or do nothing) scenario. While the adaptation scenario is costly in the short run ($150 million less in benefits than the baseline through 2025), it is preferred to the baseline scenario in the long run when those early investments begin to pay off ($410 million more in benefits than the baseline

through 2040, and upward from there). By 2100, the adaptation scenario is valued at $2.18 billion above the baseline.

Implementation and Next Steps

The City of Oceanside has a number of tools that can help facilitate the implementation of the adaptation strategies identified in this Coastal Hazard Adaptation Plan, including policy, regulatory, and procedural approaches. These include the General Plan, Local Coastal Program, Hazard Mitigation Plan, Oceanside Harbor Maintenance Dredging Plan, and administrative policies, procedures, and initiatives. There are a variety of approaches that the City of Oceanside could take to implement adaptation strategies, including coordination with regional, state, and federal agencies, engagement and communication with the community, and regulatory and policy standards for public and private development in hazard areas.

Adaptation planning is a challenging undertaking that requires significant funding. The City of Oceanside has the ability to seek federal and state grant funding in addition to implementing local funding strategies. The Federal Emergency Management Agency, the California Department of Fish and Wildlife, the California Natural Resource Agency, and the California Department of Transportation have grant programs to provide assistance to local governments. Locally, the City of Oceanside could initiate a variety of funding mechanisms (such as abatement and financing districts, in-lieu fees, or green bonds) to generate a funding reserve for adaptation strategy implementation.

The immediate next steps for the City of Oceanside to begin implementation of this Coastal Hazard Adaptation Plan are:

1. Evaluate and prioritize adaptation strategies – decide which of the recommended adaptation strategies are most relevant, most achievable, or of highest priority for implementation.
2. Phase and implement – identify a responsible or lead department, develop action plans with funding sources that articulate the steps necessary to implement the strategies, including updates to the Local Coastal Program, Capital Improvement Plan/Program and other City of Oceanside tools, and develop a monitoring program to track progress.

Section 1

INTRODUCTION

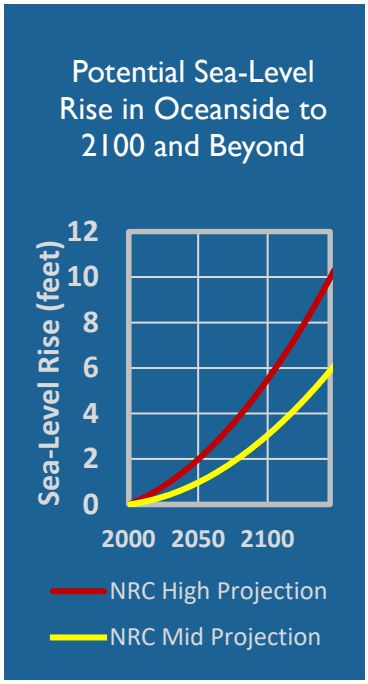
Future sea-level rise is expected to create a permanent rise in ocean water levels that would shift the water's edge landward. If no action is taken, higher water levels would increase erosion of the beaches, cause a loss of sand, and result in a narrower beach. Additionally, the combination of higher ocean water levels and beach erosion would result in greater flooding and damage during coastal storms. This document, the *City of Oceanside Coastal Hazards Adaptation Plan*, identifies a variety of adaptation strategies to help property owners (public and private) plan for and address future sea-level rise, storm surge, coastal flooding, and erosion. It provides a framework for the City of Oceanside (City) to monitor effects of coastal erosion and flooding with sea-level rise and to prepare for identified vulnerabilities by choosing from a toolbox of adaptation strategies. This Coastal Hazards Adaptation Plan (Adaptation Plan) provides the City flexibility in choosing appropriate adaptation strategies over time, as specific, quantifiable triggers for action are reached. Since project-level planning and approvals are required to further develop and implement adaptation strategies, the Adaptation Plan identifies approximate lead times that allow the City to plan for adaptation before implementation is needed. This planning effort will help to establish community consensus as well as reasonable expectations for stakeholders likely to be impacted by coastal hazards and related adaptation strategies.

Consistent with California Coastal Commission (CCC) Sea-Level Rise Policy guidance (Section 2.6), this Adaptation Plan includes a variety of adaptation approaches, including engineered and nature-based/green infrastructure solutions, as well as holistic, multi-objective measures that incorporate economic, environmental, and social considerations. Given the uncertainty in sea-level rise projections and erosion/flood modeling, planning for sea-level rise generally calls for a phased approach involving both near-term and long-term adaptation strategies. A phased approach provides a way to manage the inherent uncertainty in the timing and extent of potential sea-level rise impacts.

In August 2016, the City received a grant from the CCC to provide a comprehensive update to the Local Coastal Program (LCP) based on two published CCC documents: the LCP Update Guide and Sea Level Rise Policy Guidelines (Section 2.1.2). The LCP is a planning document that regulates development in the City's coastal zone and establishes a long-range vision for

the community (Section 2.2). In coordination with the CCC, the City is currently preparing an update to its LCP that, in part, addresses anticipated sea-level rise and its effects on coastal erosion and flooding.

In 2018, Environmental Science Associates (ESA) performed a vulnerability assessment to depict existing conditions along the City's coastline and illustrate the future vulnerability of Oceanside's social, economic, and physical coastal resources to projected sea-level rise, coastal flooding, and erosion. The assessment is documented in the *City of Oceanside Coastal Hazards Vulnerability Assessment* (VA) (ESA 2018). The VA was based on State guidance, which recommended using sea-level rise projections from the National Research Council (NRC) (2012), and the Coastal Storm Modeling System, or CoSMoS, developed by the United States Geologic Survey. The findings of the VA have informed the identification of the adaptation strategies included in this Adaptation Plan. The VA and this Adaptation Plan will be used to develop policy language for incorporation into the City's LCP.



The Adaptation Plan focuses on three hazard areas identified in the VA (**Figure 1-1**):

1. Coastal flooding and beach erosion – this includes the entire Oceanside shoreline. Properties and structures along the coast are at risk from flooding during major coastal storm events, which could become worse as the beach erodes with sea-level rise over time.
2. River and creek flooding – this includes the areas along the San Luis Rey River, Loma Alta Creek, and Buena Vista Creek. All three areas have already experienced flooding during large rainfall events and flooding is expected to increase with sea-level rise.
3. Harbor and Pier flooding – this includes the shoreline from the San Luis Rey River north to the city's northern boundary and the Oceanside Pier (Pier). Increasing tide levels and extreme flood events are expected to flood the Oceanside Small Craft Harbor (Harbor) and Pier more frequently with sea-level rise.

The Adaptation Plan is organized as follows:

- Section 2 outlines the various plans and guidelines relevant to coastal hazard planning;
- Section 3 provides an overview of an adaptation planning framework, including guiding principles, and the steps necessary to monitor change, implement project-level planning, and re-evaluate and update the Adaptation Plan as necessary;
- Section 4 introduces the ideas of an adaptation toolbox, which provides a variety of adaptation options;
- Sections 5-7 presents the adaptation strategies applicable to each of the three hazard areas listed above;

- Section 8 presents the adaptation scenario analysis including an economic assessment; and,
- Section 9 identifies funding mechanisms and policy approaches to facilitate implementation of adaptation strategies, and immediate next steps.

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SOURCE: FEMA, USGS

City of Oceanside- LCP Update

Figure 1-1
Adaptation Plan
Hazard Areas

ESA

Section 2

RELEVANT PLANS AND GUIDELINES

The Adaptation Plan is consistent with the California Coastal Act and relevant City and State policy, plans, and guidelines, as described below.

2.1 California Coastal Act

In 1976, the California Legislature enacted the Coastal Act, which requires coastal cities and counties to protect coastal resources and maximize public access to the shoreline through a comprehensive planning and regulatory program called an LCP. Pursuant to Section 30001.5 of the Coastal Act, the state's basic goals for coastal zones are to:

1. Protect, maintain, and where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and manmade resources;
2. Assure orderly, balanced utilization and conservation of coastal zone resources taking into account social and economic needs of the state;
3. Maximize public access to and along the coast and maximize public recreational opportunities in the coastal zone consistent with sound resource conservation principles and constitutionally protected rights of private owners;
4. Assure priority for coastal-dependent development over other development on the coast;
5. Encourage state and local initiatives and cooperation in preparing procedures to implement coordinated planning and development for mutually beneficial uses, including educational uses, in the coastal zone.

The Coastal Act requires all local governments located within the coastal zone to prepare an LCP. The two primary components of an LCP are the Land Use Plan and the Implementation Plan. The Land Use Plan establishes the kinds, locations, and intensities of new development allowed in the coastal zone, applicable resource protection and development policies, and other policies as necessary to achieve the objectives of the Coastal Act. The Implementation Plan typically consists of zoning regulations that establish development

standards and procedural requirements that govern development within the jurisdictional area of the LCP. The Coastal Act provides that once an LCP is certified by the CCC, the local government assumes responsibility for issuing Coastal Development Permits for most development within its jurisdiction.

The City is certified to grant Coastal Development Permits for nearly all development projects within the coastal zone. Portions of the City are subject to the permitting or appeals authority of the CCC based on criteria established in the Coastal Act. The CCC retains permitting authority over development occurring on tidelands, submerged lands (mean high tide line and seaward), and public trust lands, as stated in Section 30519(b) of the Coastal Act.

Coastal Development Permits for any development that constitutes a major public works project or a major energy facility may be appealed to the CCC. Action by the City on a Coastal Development Permit within the Appeals Jurisdiction may also be appealed to the CCC.

This Adaptation Plan seeks to proactively plan for and minimize hazards associated with sea-level rise. Implementation of this Adaptation Plan will serve as one of several tools that the City will use to protect, maintain, and enhance the overall quality of the coastal zone, consistent with the Coastal Act's goals. This Adaptation Plan also identifies adaptation strategies that seek to protect Oceanside Harbor and public access to and along the coast, including the Oceanside beaches, the Strand, the Pier and amenities along the beach, consistent with Coastal Act goals to prioritize coastal-dependent development and maximize public access.

2.2 Oceanside Local Coastal Program (LCP)

In August of 2016, the City of Oceanside was awarded a grant from the CCC to update the LCP LUP, including the preparation of a coastal hazards vulnerability assessment and an adaptation plan. The IP will be updated in subsequent phases of the LCP update process.

Oceanside's LCP guides the development review process within the coastal zone and promotes the protection and enhancement of coastal resources, including those that provide public access to the coastline and ocean (City of Oceanside 1986). Consistent with the California Coastal Act of 1976, the City's LCP includes policies that address coastal access, recreation and visitor-serving uses, water quality, natural habitat, scenic and visual resources, new development, energy and industrial uses, and shoreline protective devices. Relevant policies are described throughout this Adaptation Plan.

2.3 Oceanside General Plan

California State Government Code Section 65300 requires that every city adopt a General Plan, referred to as a City's blueprint for growth and development. The City's General Plan is comprised of ten elements, several of which address the preservation and management of coastal resources, including the Land Use Element, Environmental Resources Management Element, Community Facilities Element, Public Safety Element, and the Economic Development Element.

The Land Use Element of the City's General Plan refers to the City's LCP as the guiding policy document for the City's coastal zone (City of Oceanside 1986).

The Environmental Resources Management Element (ERME) of the General Plan includes goals and policies addressing coastal preservation (City of Oceanside 1975a). The ERME commits the City to cooperating with state and federal government agencies to "resolve the problem of beach erosion." The ERME calls upon the City to "review and develop plans for the wise utilization of the coastal areas for the general welfare and socio-economic benefit of the community as a whole, taking into consideration the environmental recommendations of the CCC, the Natural Flood Insurance Administration, and other governmental agencies dealing with the planned management and preservation of coastal resources."

The Community Facilities Element of the General Plan calls for the provision of adequate public facilities and services to protect the health, safety, and welfare of Oceanside residents and property (City of Oceanside 1990). This element commits the City to identifying and mitigating potential hazards related to natural disasters, including floods and storms. This element also encourages actions that promote the long-term viability and improvement of the Oceanside Small Craft Harbor (Harbor), including efforts to correct shoaling and wave surge in and around the harbor.

The Public Safety Element of the General Plan calls upon the City to consider the potential for flooding when making land use decisions and ensuring public awareness of flooding hazards (City of Oceanside 1975b).

The Economic Development Element (EDE) of the General Plan recognizes the City's coastal areas as visitor destinations that support the City's growing hospitality sector (City of Oceanside 2019). The EDE promotes the preservation of coastal resources as key to the City's long-term economic development.

2.4 Multi-Jurisdictional Hazard Mitigation Plan

The Multi-Jurisdictional Hazard Plan adopted in 2010 was developed with the participation of all jurisdictions in the county, including every incorporated city and the county (San Diego County 2010). The plan is intended to serve many purposes, including to: enhance public awareness and understanding, create a decision tool for management, promote compliance with state and federal program requirements, enhance local policies for hazard mitigation capability, provide inter-jurisdictional coordination of mitigation-related programming, and achieve regulatory compliance. The plan includes an overview of the risk assessment process, identification of hazards present in each jurisdiction, hazard profiles, and vulnerability assessments. It also identifies goals, objectives, and actions for each jurisdiction in the County of San Diego. The Plan is

currently undergoing revision to include an evaluation of the impact climate change will have on the natural hazards that face the County.

Section 5.14 of the San Diego County Multi-Jurisdictional Hazard Mitigation Plan is specific to the City and provides a summary of potential hazard-related exposures; administrative, technical, legal and fiscal capabilities for implementing hazard mitigation activities; goals, objectives and actions; and an action prioritization and implementation plan. The top five hazards identified in the plan for Oceanside are:

1. Coastal Storms/Erosion/Severe Weather: Constant and historical, history
2. Human caused hazards: Spills, releases, accidents, criminal activity, terrorist activity, history
3. Earthquake and Tsunami: Proximity to local faults and Pacific Ocean, history
4. Flooding: 25, 50 & 100 year storms and vegetation clogged river/creek channels, history
5. Wildfire: Climate, location, and natural vegetation types, history

The Plan establishes goals that seek to promote disaster-resistant future development, promote public understanding, support and demand for hazard mitigation, build local capacity to continuously become less vulnerable to hazards, improve hazard mitigation and coordination with other agencies and governments, and reduce the possibility of damage and losses to life, property and the environment due to earthquakes, tsunamis, flooding, sea-level rise, wildfires, costal storms, erosion, and severe weather, and human caused hazard.

2.5 Coast Highway Vision and Strategic Plan

The Coast Highway Vision and Strategic Plan provides policy direction for roadway and streetscape improvements along Coast Highway as well as modifications to land use and zoning standards that promote the revitalization of private property within the Coast Highway corridor (City of Oceanside, 2009). The Coast Highway Vision and Strategic Plan also promotes enhancement of pedestrian and bicycle access to the coastline and ocean with sidewalk improvements and new bicycle lanes on Coast Highway. While most of Coast Highway lies outside of hazard zones identified in the VA, those segments of the roadway that cross coastal watersheds (i.e., Loma Alta Creek and Buena Vista Lagoon) are vulnerable to inundation associated with sea level rise, high tide events, and coastal storms.

2.6 CCC Sea-Level Rise Policy Guidance

The purpose of the CCC Sea-Level Rise Policy Guidance document is to aid jurisdictions in incorporating sea-level rise into LCPs, Coastal Development

Permits, and regional strategies (CCC 2018). The document outlines specific issues that policymakers and developers may face as a result of sea-level rise, such as extreme events, challenges to public access, vulnerability and environmental justice issues, and consistency with the California Coastal Act. It organizes current science, technical, and other information and practices into a single resource to facilitate implementation of the Coastal Act by coastal managers at the state and local level. The document also lays out the following recommended planning steps to incorporate sea-level rise into planning strategies to reduce vulnerabilities and guide adaptation planning:

1. Step 1. Determine a range of sea level rise projections relevant to LCP planning area/segment using best-available science, which is currently the 2018 Ocean Protection Council SLR Guidance.
2. Step 2. Identify potential physical sea level rise impacts in the LCP planning area/segment, including inundation, storm flooding, wave impacts, erosion, and/or saltwater intrusion into freshwater resources.
3. Step 3. Assess potential risks from sea level rise to coastal resources and development in the LCP planning area/segment, including those resources addressed in Chapter 3 of the Coastal Act.
4. Step 4. Identify adaptation measures and LCP policy options to include in the new or updated LCP, including both general policies and ordinances that apply to all development exposed to sea level rise, and more targeted policies and land use changes to address specific risks in particular portions of the planning area.
5. Step 5. Draft updated or new LCP for certification with CCC, including the Land Use Plan and Implementing Ordinances.
6. Step 6. Implement the LCP and monitor and re-evaluate strategies as needed to address new circumstances relevant to the area.

The document has a strong emphasis on using soft or green (i.e., nature-based) adaptation strategies. It was updated in 2018 to reflect updated best available science consistent with reports released by the Ocean Protection Council (Rising Seas in California: An Update on Sea-Level Rise Science and State of California Sea-Level Rise Guidance: 2018 Update). This Adaptation Plan was prepared in accordance with the CCC Sea-Level Rise Policy Guidance document.

2.7 State of California Sea-Level Rise Guidance

The State of California Sea-Level Rise Guidance document provides a science-based methodology for state and local governments to analyze and assess the risks associated with sea-level rise, and to incorporate sea-level rise into their planning, permitting, and investment decisions (California Ocean Protection Council 2018). The document provides a synthesis of the best available science on sea-level rise projections and rates for California; a step-by-step approach for state agencies and local governments to evaluate those projections and

related hazard information in decision making; and preferred coastal adaptation approaches. The document is consistent with the California Ocean Protection Council's commitments to use the best available science in the management of ocean resources, to employ a precautionary approach in the face of scientific uncertainty, and to improve coordination across government agencies in addressing the complex challenges of climate change. The document was updated in 2018 to focus on the needs of both state agencies and local governments and to reflect recent advances in ice loss science and projections of sea-level rise. The VA relied on the sea-level rise projections associated with the previous version because the State of California Sea-Level Rise Guidance document was updated after the preparation of the VA had begun.

2.8 Safeguarding California Plan: 2018 Update, California's Climate Adaptation Strategy

The Safeguarding California Plan: 2018 Update, California's Climate Adaptation Strategy provides a comprehensive suite of ongoing and needed adaption actions by state agencies responding to climate change. It serves as a roadmap of the ongoing actions and next steps being taken by California's state government to make its people, economy, and environment more resilient to the impacts of climate change. The document includes principles and recommendations that provide policy directives and a conceptual framework for the hundreds of adaptation initiatives across state government. The document first describes overarching strategies recommended by the California Natural Resources Agency (the State's lead agency on climate change adaption), then outlines ongoing actions and cost-effective next steps to make California more resilient to climate change. Recommendations and policy directives are organized across the following 11 sectors: emergency management, energy, land use & community development, public health, transportation, agriculture, biodiversity and habitat, forests, ocean and coast, and water. Climate justice-related recommendations and policy directives are pulled from the 11 sector-specific policy areas into one overarching chapter. The following are recommendations (or goal statements) for the ocean and coast sector:

1. Support planning and adaptation to reduce hazards and to increase the resilience of coastal communities, infrastructure, development, and other resources.
2. Design and implement nature-based projects to protect and enhance the adaptive capacity of coastal and marine ecosystems, including beaches and wetlands.
3. Develop actionable science that reflects the latest and evolving trends over a range of spatial and temporal scales.
4. Continue to assess community and ecosystem vulnerability to climate impacts.

5. Provide pathways for meaningful community engagement (such as education and outreach) in coastal decision-making processes.
6. Coordinate across agencies and external partners to ensure efficient problem solving and widely communicate resources for ocean and coastal adaptation strategies.

The document is not intended to establish guidelines for local governments on how to adapt to climate change nor does it detail all actions that need to or should be taken by local governments. However, it does provide an extensive suite of goals and policies (or strategies) for various sector-specific areas.

2.9 California Adaptation Planning Guide

The California Adaptation Planning Guide (APG) provides a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development (California Natural Resources Agency and California Emergency Management Agency 2012). The APG is meant to be a resource for communities seeking to be in compliance with Senate Bill 379 which requires Safety Elements of General Plans to consider climate change.

The APG includes a Planning Guide overview document and three companion documents for use in various combinations:

- APG: Planning for Adaptive Communities – This document presents the basis for climate change adaptation planning and describes a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development.
- APG: Defining Local and Regional Impacts – This document provides a more in-depth understanding of how climate change can affect a community. Seven "impact sectors" are included to support communities conducting a climate vulnerability assessment, including an ocean and coastal resources sector.
- APG: Understanding Regional Characteristics – The impact of climate change varies across the state. This document identifies climate impacts by region, including the central coast, as well as regional environmental and socioeconomic characteristics.
- APG: Identifying Adaptation Strategies – This document explores potential adaptation strategies that communities can use to meet varying adaptation needs. The adaptation strategies are organized by the following sectors: public health, socioeconomic and equity, oceans and coastal resources, water management, forest and rangeland, biodiversity and habitat, agriculture, and infrastructure. The following are the adaptation strategies identified for oceans and coastal resources:

    1. Develop an adaptive management plan to address the long-term impacts of sea- level rise.

2. Facilitate managed retreat from, or upgrade of, the most at-risk areas.
3. Require accounting of sea-level rise in all applications for new development in shoreline areas.
4. Preserve undeveloped and vulnerable shoreline.
5. Use transfer of development rights (TDR) for the rebuilding of structures damaged or destroyed due to flooding in high-risk areas.

2.10 Oceanside Harbor Maintenance Dredging Plan

The Oceanside Harbor is a federal navigation channel, which requires inlet maintenance per the 1944 Flood Control Act and 1946 Rivers and Harbor Act. Per the federal Oceanside Harbor Maintenance Dredging Plan, U.S. Army Corps of Engineers (USACE) is responsible for the annual dredging of the Entrance Channel, Oceanside Channel, and Del Mar Channel to design depths (-25 feet mean lower low water (MLLW) for the entrance channel, -20 feet MLLW for the Oceanside and Del Mar Channels). Until 2010, the dredged sediment was primarily placed south of the Pier beginning at Tyson Street (Joe Ryan, personal communication). Since 2010, dredged material has been placed in areas with decreasing beach widths, notably the stretch between the San Luis Rey River and Tyson Street, in front of the Lifeguard Headquarters at the Pier, the North Coast Village, and nearshore at Forster Street (Joe Ryan 2017). If excess dredged material remains following placement at priority locations, additional beach nourishment begins at the Pier and continues southward.

Annual dredge volumes vary but average between 180,000-200,000 cy (USACE 2017, Joe Ryan 2017). Dredging and beach nourishment typically occur during the spring. The City maintains harbor dredge and beach nourishment records beginning in 1942 and has beachfill reports beginning in 2008.

Section 3

ADAPTATION PLANNING FRAMEWORK

The Adaptation Plan provides a framework for the City to monitor the effects of coastal erosion and flooding exacerbated by sea-level rise and prepare for identified vulnerabilities by choosing from a toolbox of adaptation options. Coastal hazard adaptation should be flexible as sea-level rise science advances, actual conditions are monitored into the future, and strategies are tested. Strategies should reflect the Oceanside community's risk tolerance, local conditions, and adaptation vision. Project-level planning and approvals will be required to further refine, finance, and implement the adopted adaptation strategies. Accordingly, lead times for project-level planning are identified that allow the City to plan for adaptation before implementation is needed.

In accordance with CCC Sea-level Rise Policy guidance (CCC 2018), the Oceanside Adaptation Plan:

- Is based on the best available science and adaptation practices available today;
- Acknowledges that sea-level rise science and practices are evolving and that the City will evaluate future decisions and take action based on the best-available science and technology at the time; and
- Includes a range of sea-level rise adaptation strategies within the three general categories of adaptation: Protect, Accommodate, and Retreat.

The CCC further advises that, after evaluating vulnerability and establishing policies for areas with identified hazards, communities can begin the process of evaluating and choosing adaptation strategies for those areas. In most cases, multiple adaptation strategies will be needed to address a range of conditions and potential impacts. There are a number of ways to address the risks associated with sea-level rise. Choosing to do nothing or following a policy of non-intervention will likely lead to unacceptable exposure and impacts to many coastal resources. Without proactive planning, impacts will likely be more frequent and costlier to address. For instance, simply maintaining an asset in a vulnerable location and repairing or replacing it whenever it is damaged or destroyed may prove to be a more expensive and less sustainable strategy than

relocating the asset or redesigning it to be more resilient to inundation and wave action. Moreover, a failure to plan for potential impacts could result in significant interruptions in the provision of essential services, due to damaged infrastructure, barriers to emergency response, etc. Identifying and addressing potential impacts proactively can keep both people and property out of harm's way, thereby enhancing public safety, safeguarding resources, and reducing costs.

3.1 Guiding Principles

The following principles should be considered when prioritizing and selecting adaptation strategies to address the project impacts of sea-level rise and related hazards.

1. Preserve and enhance the following features and activities:
   - Beach and ocean
   - Public amenities
   - Scenic resources
   - Natural habitat
   - Commercial goods and services
   - Arts and entertainment
   - Community events
   - Public parking
2. When evaluating adaptation options, the following should be considered:
   - Coastal access
   - Public safety
   - Visual quality/community character
   - Natural resources
   - Private property rights
   - Economic development
   - Fiscal health
   - Legal exposure/indemnity
   - Flexibility
3. Minimize the impacts of sea-level rise and related hazards by
   - Using science to guide decisions, with considerations for
     - local conditions,
     - scenario planning, and

    - a precautionary approach;
  - Minimizing vulnerabilities through planning and development standards that consider
    - new development,
    - social and economic needs of the community, and
    - an assumption of risk.

4. Consider and prioritize the following resources in our assessment of adaptation options:
  - Maximize protection of public access, recreation, and sensitive resources by preserving
    - natural shoreline values and processes,
    - public trust lands, and
    - mitigating unavoidable impacts;
  - Maximize
    - coordination with regional, state, and federal agencies,
    - participate in regional vulnerability assessment and planning, and
    - foster public participation.

3.2 Monitoring Change

The Adaptation Plan includes measurable triggers that, if and when they occur, call for the implementation of adaptation strategies to limit risks. The Adaptation Plan sets planning-level adaptation triggers such that adaptation strategies can be implemented to reduce future risks before they become critical. The City will need to monitor and evaluate the trajectory towards these triggers to track whether and when these triggers are met. Adaptation triggers and monitoring are summarized below.

3.2.1 Height of Sea-Level Rise

Certain adaptation strategies will need to be triggered when sea-level rise has risen by a certain amount (e.g., 1 ft, 2 ft, and 3 ft of sea-level rise). To monitor sea-level rise and progress towards the sea-level rise amount triggers, the City will follow sea-level rise reports from the State and Scripps Institute of Oceanography and sea-level rise data from the nearby National Oceanic and Atmospheric Administration (NOAA) tide gage at Scripps Pier at La Jolla Shores. These include:

- CCC Sea-Level Rise Policy Guidance: initially adopted August 2015, updated November 2018 (https://www.coastal.ca.gov/climate/slrguidance.html)

- Ocean Protection Council State of California Sea-Level Rise Guidance: initially released in 2010, updated in 2013, and updated in 2018 (http://www.opc.ca.gov/updating-californias-sea-level-rise-guidance/)
- California Climate Assessment: initially released in 2006, updated in 2009, updated in 2012, and updated in 2018 (http://www.climateassessment.ca.gov/)
- NOAA Tides and Currents for Station ID 9410230: updated regularly (https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9410230)

While astronomical tides are predictable, sea-level is inherently variable in response to less-predictable atmospheric events such as El Niño and individual storms. However, sea-level rise can increase the impacts of fairly routine storms that already impact Oceanside's coastline, by creating higher water levels to begin with. Tracking sea-level rise may, therefore, allow the City to anticipate and act in advance of the projected effects of sea-level rise.

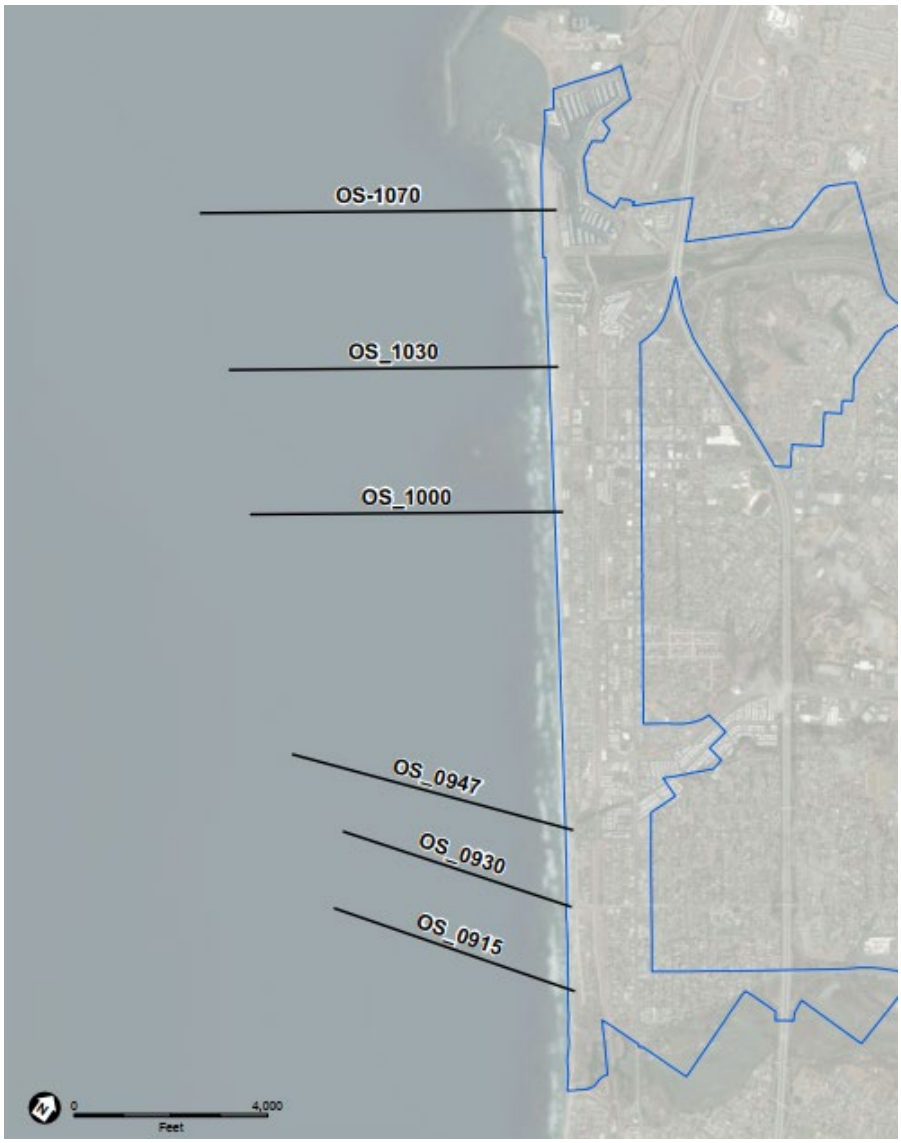
3.2.2 Flooding and Storm Damage Frequency

In addition to the amount of sea-level rise, the frequency or risk of flooding and storm damage can be used as a trigger for adapting to coastal hazards. To monitor the frequency of flooding and storm damage, the City can track and keep records of coastal and river flooding and storm damage events and information. This could be a collaborative effort between City staff and residents in which reports, pictures, and videos are collected. The date, type, location, and severity of flooding (e.g., depth, duration, wave height), and damages can be collated into a file. The intent will be to track the frequency, extent, and severity of flooding to identify trends as well as significant anomalies. When significant and/or extreme flood events occur, storm data (e.g., water levels, wave conditions) can be collected and storm frequencies can be recalculated to quantify any increase in flood risk.

3.2.3 Beach Width

Considering the recreational and ecological values of maintaining a beach, as well as the erosion and flooding buffer that beaches provide, beach width is used in this Adaptation Plan for considering when beach adaptation strategies would be implemented (sand placement, construction/maintenance of shoreline protection structures). Specific beach width triggers are discussed in Section 4 and should be further detailed as part of subsequent monitoring, analysis, and planning subsequent to this study. The San Diego Association of Governments (SANDAG) currently performs topographic beach profile surveys to monitor beach width at six locations in Oceanside, shown in **Figure 3-1**. Profiles have been surveyed two times per year since 1999. The City should review the results of beach surveys from SANDAG, and assess the results against beach width triggers. Supplemental and long-term beach monitoring programs that

include all of Oceanside's beaches are recommended for consideration as part of the implementation of the Adaptation Plan.



Source: SANDAG 2016

Figure 3-1. SANDAG Monitoring Profile Locations

3.2.4 River/Creek Channel Deposition

Per the VA (ESA 2018), the potential for increased amounts of sand building up in the mouths and channels of San Luis Rey River and Loma Alta Slough with sea-level rise is a significant factor in increasing the City's risk of river/creek flooding. The amount of channel deposition is, therefore, used as a trigger for river/creek flooding adaptation strategies. The City should consider monitoring channel elevations through topographic surveys.

3.3 Project-Level Planning

The Adaptation Plan identifies potential adaptation strategies at a conceptual planning level of detail (e.g., high-level overview) and discusses potential benefits and adverse effects of adaptation strategies. Additional detailed project-level planning and design will be required to implement adaptation strategies. For adaptation strategies involving construction (e.g., shoreline protection devices), the project-level planning and design may include:

- Feasibility study including additional technical analyses, development, and assessment of project alternatives and details, conceptual and preliminary engineering design, and cost estimating.
- Community and stakeholder engagement to solicit input on the project alternatives and design details.
- Environmental review and regulatory permitting in accordance with the California Environmental Quality Act and possibly National Environmental Policy Act. Proposed projects could require approvals and permits from the USACE, US Fish and Wildlife Service, NOAA, California State Lands Commission, CCC, California Department of Fish and Wildlife, as well as other Federal and State agencies.
- Final engineering design.

Lead time is required to perform project-level planning, secure funding, and implement or construct an adaptation strategy. All adaptation options discussed in the Adaptation Plan require substantial lead time (e.g., the strategies in this plan are not build-ready). For example, levees, comprehensive armoring, and sand retention strategies can require significant lead time. With anticipated lead times, the City will be able to begin advanced planning before adaptation strategies would need to be in place to limit risk.

3.4 Reevaluation

The Adaptation Plan establishes a process through which new data and information will be assessed, as needed, to inform adaptation decisions and actions. As such, it is anticipated that the Adaptation Plan will be re-evaluated and updated in the future to capture advances in sea-level rise science and adaptation strategies.

Section 4

ADAPTATION TOOLBOX

Designed by Macroector/Freepik

Having an adaptation toolbox will allow Oceanside to start planning now for both near-term strategies and those that will take a long time and many resources to implement.

Considering all sea-level rise adaptations in an adaptation "toolbox" allows Oceanside to respond to the threat of rising sea levels with a variety of strategies appropriate for different circumstances. For example, certain strategies, like beach nourishment, are generally more useful in reducing coastal flooding as opposed to flooding in the riverine setting. Other strategies may work for a certain time horizon, but might not be feasible with large amounts of sea-level rise, or, visa-versa, may take a long time and significant resources to implement. Developing an adaptation toolbox does not commit Oceanside to any one strategy, but allows the City to consider all the available options.

To implement any adaptation strategy, project-level planning and approval processes are required, which take time and effort. None of the adaptation strategies presented in this plan can be implemented overnight, so the toolbox includes adaptation strategies, such as managed retreat, that may not be implemented anytime soon, but that require planning now, well before implementation needs to occur. Planning efforts can involve the monitoring of conditions, preemptive changes to regulations and procedures, educational programs, and financing mechanisms, etc.

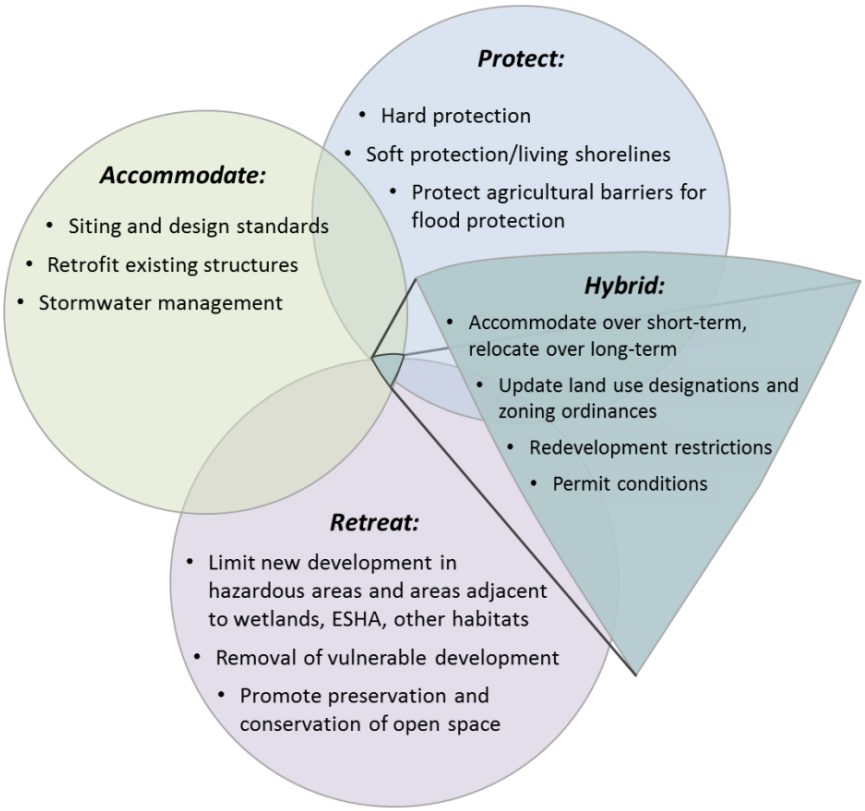
4.1 General Adaptation Approaches

Adaptation strategies are typically organized within the following categories (**Figure 4-1**):

- **Protection strategies**, which employ some sort of engineered structure or other feature to defend development or other resources in their current location without changes to these resources themselves. Examples include shoreline protective devices such as seawalls, revetments, groins, and breakwaters, which defend against coastal hazards like wave impacts, erosion, and flooding; natural or "green" methods like beach nourishment and artificial dunes, to buffer coastal areas; and hybrid approaches that employ both artificial and natural infrastructure.
- **Accommodation strategies**, which involve modifying existing assets or designing new assets in a way that increases their ability to withstand

flooding and other anticipated impacts. Examples include elevating and/or retrofitting structures and using materials that increase their strength and resiliency. In Oceanside, this could include flood proofing the first floor of buildings to accommodate high-water-level events.

- **Retreat strategies**, which involve relocating or reducing the footprint of existing assets so as to move them out of hazard areas, and limiting the siting of new development in hazard areas (typically through the use of minimum setback requirements). Relocation of development in Oceanside will be most feasible in locations where the City owns and controls the underlying property. Examples where this strategy is most likely to be used include relocation of public facilities, roads, and infrastructure. Relocating private development can be a more difficult undertaking, but, in some cases, there may be no reasonable alternative. Depending on the level of risk associated with replacing damaged resources or siting new resources in hazard zones, the City may not be in a position to approve such actions – particularly where there is sufficient evidence that new or replacement resources will be subject to flooding or other impacts.



Source: CCC 2018

Figure 4-1. Examples of general adaptation strategies

Different types of strategies will be appropriate in different locations, and in some cases a hybrid approach with strategies from multiple categories may be the best option. Additionally, the suite of strategies chosen may need to

change over time, as conditions change and previous areas of uncertainty and unknown variables become more certain.

4.2 Oceanside Adaptation Toolbox

The VA identified the degree of vulnerability the Oceanside beaches, rivers and creeks, visitor-serving amenities, public access areas, residential and commercial areas, and public facilities and infrastructure could face as a result of sea-level rise. This Adaptation Plan provide tools for the community and the City to manage risks and take actions focusing on three hazard areas:

- Coastal flooding and beach loss,
- Low-lying areas along the river/creeks, and
- Harbor inundation due to tides and extreme water levels and a less-effective breakwater.

Sections 5-7 provide specific adaptation tools for each of these vulnerabilities.

Section 5

COASTAL FLOODING AND BEACH EROSION ADAPTATION

This section presents the vulnerability due to coastal flooding and beach erosion in the low lying coastal areas of the city, monitoring to identify increasing risks, adaptation options to address the risk, and the recommended adaptation strategies for Oceanside.

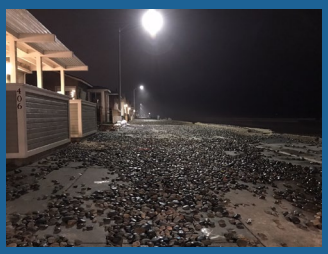
5.1 Vulnerability of Coastal Areas to Coastal Flooding and Beach Erosion

Oceanside is currently vulnerable to tidal inundation, coastal storm flooding, wave impact, and beach erosion. As described in Section 3 of the VA, extreme coastal flood events that have caused significant damage have occurred in Oceanside in 1939, 1940-41, 1978, 1980, 1983, and 1998, as well as more recent flooding.

As shown in Appendix A of the VA, the beach in Oceanside is generally eroding south of the San Luis Rey River mouth, with some areas experiencing erosion up to 4 ft/yr in the period between 1972 and 1998. With sea-level rise, the beach is likely to continue to erode, if no adaptation strategies are implemented. **Table 5-1** presents average beach widths over time based on the CoSMoS modeling results[1] used in the VA.

Currently, areas along the Strand, and in some sections, beachfront properties inland of the Strand, experience wave damage during larger coastal storms. Cobbles from the beach have been thrown up onto the road and at properties during stormy weather (see text box to the left). The plaza, community center, and new restrooms near the Pier also have experienced wave damage and flooding during larger storms.

Cobbles were thrown on the Strand and the beach was inundated after king tides in June 2017.



Source: Johnny Lara, City of Oceanside

Video by Scott Nightingale, City of Oceanside

[1] CoSMoS was developed by the United States Geologic Survey with state funding for use in LCPs. See Section 2.1.3 in the Vulnerability Assessment for additional information on CoSMoS.

Table 5-1. Oceanside Beach Widths with Sea-Level Rise

Sea-Level Rise (ft)	0	0.8	1.6	3.3	5.7
Average Oceanside Harbor Beach width	510	300	270	170	60
Average beach width at San Luis Rey River mouth	1,050	750	750	630	530
Average beach width south of the San Luis Rey River mouth to Pier (ft)	190-220	60-100	10-50	0	0
Average beach width south of Pier to the city limits (ft)	5-90	0-50	0-20	0	0

By 2040, daily flooding during high tide is expected to be a common occurrence, even without storms, for beachfront properties starting just south of Paradise by the Sea (hotel near Breakwater Way) and extending south past Roberts Cottages. The rest of the coastline will be impacted during larger storms, with waves expected to extend inland of the Strand, potentially impacting properties along the entire coastline.

By 2070, waves during a coastal storm would start to reach some of North Coast Village. Wave action, storm flooding, and daily flooding would continue to reach farther inland into beachfront properties by 2100 but would likely not extend past the bluffs in the north (on Pacific Street) or past the first row of homes in the south by the end of the century.

5.2 Coastal Flooding and Beach Erosion Adaptation Monitoring

Factors to be monitored for coastal flooding and beach erosion adaptation include sea-level rise, changes in the frequency of extreme coastal flooding, damage to coastal assets, and approximate beach widths. The VA projected that with greater than 0.8 ft of sea-level rise, average beach widths would become too narrow to walk or recreate on and would not provide an adequate buffer for storm protection (Table 5-1). A beach width trigger should be developed based on the projections in Table 5-1 and an acceptable level of risk of flooding and damage as determined by the City. While further analysis is needed, the triggers for initiating consideration and planning for beach adaptation could be:

1. Initially, sea-level rise approaching 0.8 ft
2. Average or successive beach widths approaching 0-50 ft

SANDAG currently monitors six beach transects in Oceanside (see Appendix A of the VA). These data should be analyzed regularly to evaluate beach trends and to identify the need for adaptation strategies. Additionally, the City should

track king tides and storm events to document flood extents and damage, which will require a framework for coordination between multiple disciplines, such as Public Works, Water Utilities, Planning, and Engineering. If tracking shows an increase in flood and storm damage frequency, implementing an appropriate adaptation strategy should be considered.

5.3 Coastal Flooding and Beach Erosion Adaptation Options

Possible adaptation strategies for coastal flooding and beach erosion include:

- Coastal sediment management (e.g., beach and dune enhancement, sand bypassing)
- Sand retention structures (e.g., groins and artificial headlands, breakwaters, offshore reefs)
- Shoreline protection devices (e.g., sea walls, revetments)
- Elevation of structures and/or property grades
- Managed retreat

5.3.1 Coastal Sediment Management

Coastal sediment management is a combined strategy involving beach and dune enhancement and sand bypassing.

Beach and Dune Nourishment

Sand replenishment in Carlsbad, CA

Photo from SANDAG

Beach and dune nourishment is an adaptation strategy that provides protection against coastal storm erosion while maintaining natural beach conditions, habitat, and geomorphic processes (such as the ability of the beach to erode in response to winter storms and build up sand in response to summer wave conditions), as well as public access. Beach nourishment refers to placement of sand to widen a beach, which can be accomplished by placing a sediment-water slurry directly on the beach and/or mechanical placement of sediment with construction equipment (box to the left). Sand can be obtained from inland sources (e.g., sand trapped in reservoirs, construction projects) and can be dredged from offshore along the bottom of the ocean.

In addition to beach nourishment, dune restoration is recognized as a natural way of mitigating backshore erosion as well as maintaining a wider beach through sacrificial erosion of the dunes. Dune construction would include placing of sand, grading, and planting to form "living" back beach dunes. Dune restoration can provide aesthetic, ecology, and recreation benefits. A variant includes placement of cobble (rounded rock), which is often naturally present below beaches in California (**Figure 5-1**). Burying a layer of cobble provides a "backstop" that is more erosion resistant and dissipates waves to a greater degree. Currently, Oceanside's coastline does not include natural dunes and

likely does not have the width in most areas to accommodate dunes. Dunes could possibly be used in front of the Harbor, where the beach is the widest in the city, and possibly in conjunction with larger-scale beach nourishment in other areas of the City.

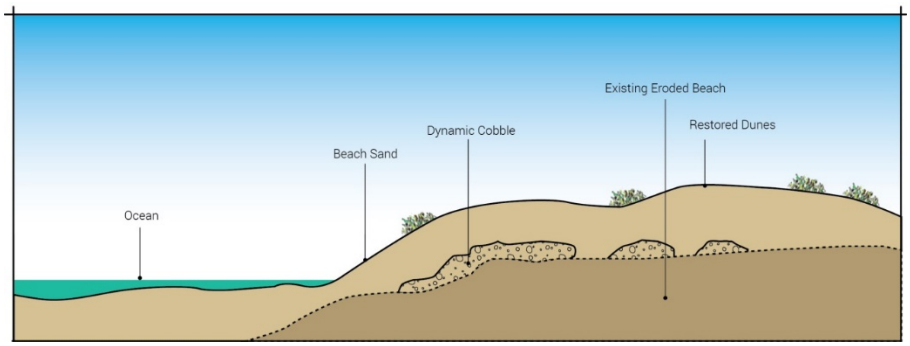
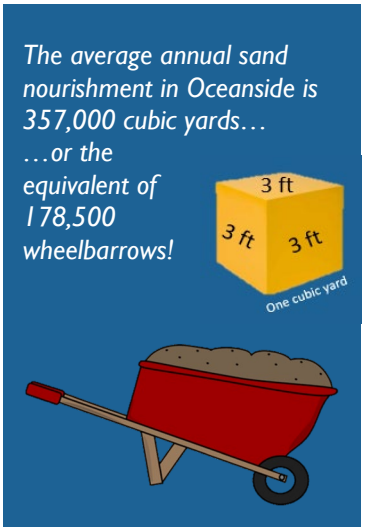


Figure 5-1. Cross-section of beach nourishment, dune restoration, and cobble placement



As discussed in Appendix A of the VA, beach nourishment is already occurring in Oceanside. However, while beach nourishment initially reduces the risk of flooding and erosion along the beach, the beach width is expected to diminish with time as sand continues to move south, requiring an ongoing cycle of "re-nourishment" to maintain the beach. For example, Oceanside has added an average of 357,000 cubic yards of sand to the beach annually since 1994. Additionally, some areas of Oceanside (e.g., south of Loma Alta Slough) do not currently have much of a beach, which would make beaches even harder to maintain in these areas without larger-scale nourishment. The narrow and seasonally non-existent beach in these areas indicates processes are already moving sand rapidly away from these spots, making nourishment challenging.

As sea level rises, the frequency of required nourishment is likely to increase, because, in addition to widening the beach to offset erosion due to more frequent and more severe storm events, additional sand will be needed to raise the elevation of the beach up to the increased sea level. The City could continue to pursue sources such as opportunistic beach nourishment (surplus sand from various sources, including inland construction or development project) or regional nourishment programs such as through SANDAG. Beach nourishment can be considered in conjunction with sand retention measures to improve the longevity of sand placements (see Section 5.2.2 below). Nourishment is expected to be effective up to 2-3 feet of sea-level rise.

Additionally, while a wider beach reduces wave energy that reaches the shore, nourishment may not protect against flooding during high water level events (e.g., a storm event or king tide event) when the beach is submerged. During large storm events, sand can be transported off the beach rapidly, reducing or eliminating the benefit of the nourishment. Restored dunes can provide storm

protection, but can also be eroded and washed out during storm events, exposing landward areas to flood risks.

Sand Bypassing

Sand bypassing is the placement of sand removed from harbor or lagoon inlets on down shore beaches. Manmade structures, such as the Harbor, interact with longshore sand transport, with sand moving into and out of the harbor inlet due to waves and currents. In general, harbor inlets act as sediment sinks, and require dredging to maintain an open inlet. The sediment that ends up in the harbor is sediment that does not make it down shore. Sand bypassing, therefore, allows sand to "bypass" the harbor (**Figure 5-2**).

Figure 5-2. Sand bypassing concept

As documented in Appendix A of the VA, the Oceanside Harbor is already regularly dredged, with sand placed in areas in Oceanside with decreasing beach widths. In most years, sand is eroded from the beach within weeks after placement, so sand bypassing may have limited benefit. The USACE has commissioned a report to study the effectiveness of sand bypassing in Oceanside. The report has been placed on-hold pending funding.

The City could also look at bypassing sand from the beach north of the harbor, where sand accumulates at the breakwater. This could partially address the interruption in the natural process of sand transport from the north caused by the Harbor, but would require coordination with Camp Pendleton.

Table 5-2 summarizes considerations for both beach and sand bypassing.

Table 5-2. Coastal Sediment Management Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$	▪ Regional funding sources and programs are available	▪ Recurring implementation cost ▪ Transportation of sand/cobble from sources to nourishment sites ▪ Limited sand sources and increased competition for sand over time ▪ Material dredged from the harbor must be evaluated for suitability for beach placement
Environment	Minor impact	▪ Preserves beach for recreation/tourism and habitat ▪ Maintains beach aesthetics	▪ Ecological impacts from pumping sand and bulldozing into place ▪ Nourishment sand can be transported down coast and contribute to closure of lagoon mouths
Flood Protection	Short-term	▪ A wider beach would reduce waves reaching the backshore	▪ Does not protect against high water level events once beach is submerged ▪ Can erode during storm events, exposing landward areas to flood risks ▪ Less effective over time with increasing sea-level rise. Likely only effective up to 2-3 ft of sea-level rise. ▪ Sand will likely erode more quickly along segments of the coast that presently have no beach ▪ Less effective without sand retention structures
Timeline to Implement		▪ Already being implemented in Oceanside	▪ Complex permitting requirements from state and federal agencies

5.3.2 Sand Retention Structures

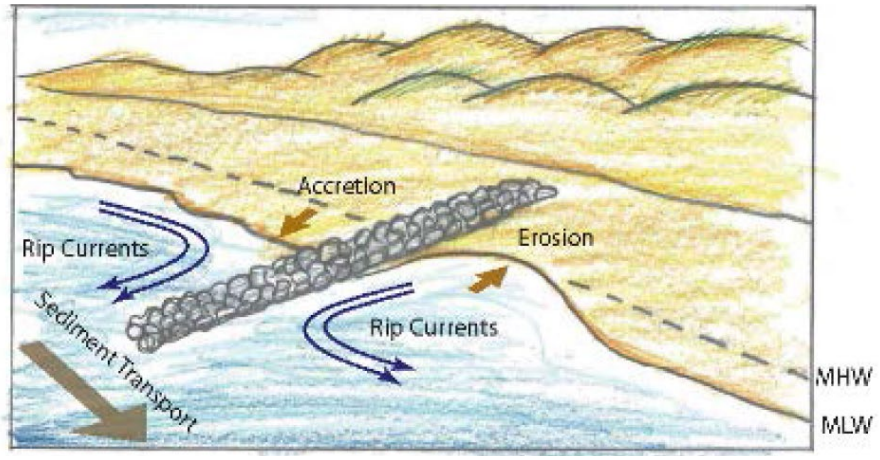
An example of a groin in El Segundo, CA

Source: Louis White, ESA

Groins

Groins extend perpendicular to the beach and trap sand from drifting downcoast (**Figure 5-3**). Where wave conditions are ideal, groins have been successfully used in California and other locations to maintain a wider beach. In other cases, groins can induce and/or accelerate erosion down-coast of the groin as shown in Figure 5-3. Groins are generally considered along stretches of coast with high net longshore sediment transport. In application, groins segment the beach and nourishment efforts into compartments, thereby reducing the loss of sand to adjacent shores.

Public access across or over the groins has the potential to negatively affect horizontal access along the beach. Constructing rock groins and other rock structures on the beach and/or in the ocean typically requires habitat mitigation (e.g., restoration of comparable habitat in another location) and could alter the character of Oceanside's natural shoreline.



Source: ESA PWA 2012

Figure 5-3. Examples of groins

The Oceanside Harbor breakwater protects the harbor behind it.

Photo from marinas.com

Breakwaters

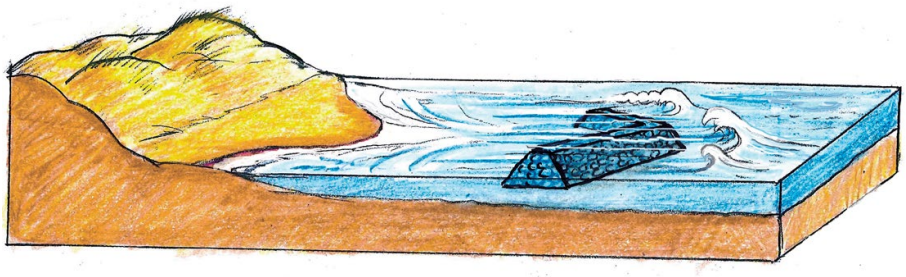
Breakwaters are offshore structures constructed parallel to the beach to reduce wave action. Typically built out of rock, breakwaters extend from the ocean floor to above the ocean level, thereby acting as a wall that blocks waves by causing them to break. Breakwaters dissipate incident wave energy and change the pattern of sand transport in their lee, thereby reducing the transport of sand. These structures are generally applicable where there is a firm seabed and the need to create a calm area free from wave energy. Breakwaters have been used to shelter shorelines and harbors (e.g., the Oceanside Harbor breakwater, photo to the left), have been built in shorter segments to encourage sand accumulation behind the breakwater segments, and in some instances can provide access and recreation.

However, breakwaters completely change wave patterns and destroy surfing resources. Due to permitting and mitigation requirements, few if any new breakwaters are being considered in California and the trend is to explore the removal of breakwaters (e.g., City of Long Beach's East San Pedro Bay Ecosystem Restoration Feasibility Study, which evaluates removal the Long Beach Breakwater).

Offshore Reefs

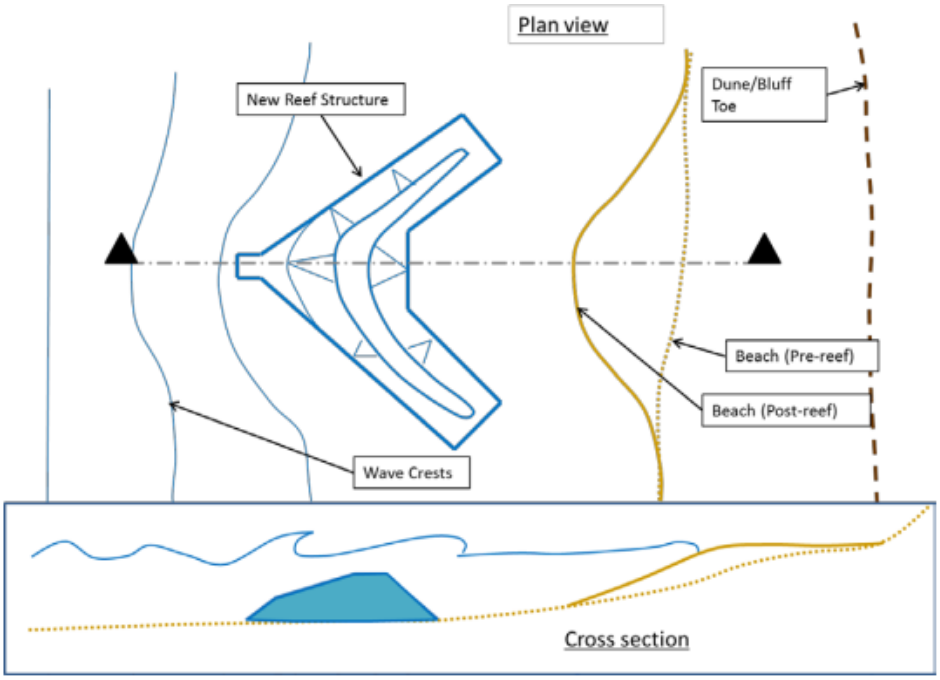
Artificial reefs are underwater offshore structures constructed of rock or other materials (**Figure 5-4**). The multi-purpose artificial reefs are intended to encourage sand retention behind the reef, provide rocky reef habitat, and can provide or enhance surfing resources (**Figure 5-5**). Because reefs are

submerged, except under low tides, they do not provide much reduction in wave energy or flooding at the shoreline. Artificial reefs installed to act as submerged breakwaters have received increased attention in recent years as a means of shore stabilization and erosion control, primarily due to their low aesthetic impact and enhanced water exchange relative to traditional emergent breakwaters (Vicinanza et al. 2009) and the potential to enhance local surfing conditions (Ranasinghe & Turner 2006).



Source: ESA PWA 2012

Figure 5-4. Example drawing of an offshore breakwater with a low crest height



Source: ESA 2015

Figure 5-5. Schematic of multi-purpose reef intended to create a surfing break

Using artificial reefs to retain sand and enhance surfing is still in the experimental phase of development. Reefs have been investigated, constructed, and tested in various locations including Orange County, but there is not

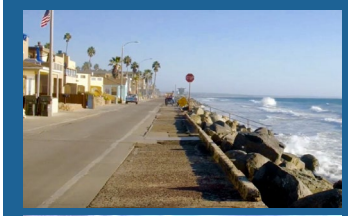
enough experience with successful reef installation to ensure that reef implementation will provide the intended benefits.

Sand retention structures, such as groins and artificial headlands, breakwaters, and offshore reefs, are intended to reduce sand transport away from the beach and encourage sand deposition on the beach. **Table 5-3** summarizes considerations for using sand retention structures.

Table 5-3. Sand Retention Structures Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$	▪ Most of cost is in one-time implementation; some maintenance	▪ In-water work is more expensive
Environmental Impact	Major	▪ Preserves beach ▪ Can improve surfing resources (reefs) ▪ Provides rocky reef habitat (reefs)	▪ Requires habitat mitigation for offshore bottom species (groins and breakwaters) ▪ Can destroy surfing resources (breakwaters) ▪ Impacts horizontal access along the beach (groin) ▪ Can induce/accelerate erosion down coast of structures
Flood Protection	Short-term	▪ Reduces flood and erosion risks by retaining sand and maintaining a wider beach ▪ Reduces wave impacts (breakwaters and reefs)	▪ Less effective over time with increasing sea-level rise ▪ Expected to be effective up to 2-3 feet of sea-level rise ▪ Provides little flood protection during high water events (groins and reefs)
Timeline to Implement	🕒🕒🕒	▪	▪ Complex permitting requirements from state and federal agencies

An existing rock revetment along the Oceanside beach protects the Strand from wave runup, but can be overtopped during storm events.



5.3.3 Shoreline Protection Devices

Shoreline protection devices, such as sea walls and rock revetments, are structures along the coast that provide flood and erosion protection for beachfront properties by absorbing or dissipating wave energy. Revetments are made up of an armor layer (e.g., rock rip-rap piled up or a carefully placed assortment of interlocking material, which forms a geometric pattern), a filter layer (which provides for drainage and retains the soil that lies beneath), and a buried toe (which adds stability at the bottom of the structure). As described in Appendix A of the VA, sea walls are the primary shoreline protection structure on the Oceanside coastline from the northern city limits to Tyson Street Park, at which point shoreline protection transitions to revetments.

Example of a seawall in Galveston, TX. The seawall spans the length of the island and protects major transportation corridors and development.

Source: www.pinterest.com/pin/560698222343847312/?lp=true

The beach in front of the seawall has eroded up to the sea wall over time.

Source: https://doi.org/10.17226/18811. https://www.nap.edu/read/18811/chapter/3

While the seawall offers protection during typical storms, it is still susceptible to overtopping during major events.

Source: https://www.swg.usace.army.mil/Business-With-Us/Emergency-Management-Office/Hurricane-Response/

During severe storms, which can be coupled with severe seasonal erosion of the beach, waves can overtop the sea walls and revetments and cause damage (photo to the left). Raising and improving the Oceanside sea walls and revetments is an adaptation strategy that could offset the increase in flood risk with sea-level rise. This could be accomplished by adding a new section of sea wall or rock to the top of the existing walls/revetments. However, doing so may require significant modifications or a rebuilding of the existing walls/ revetments.

While sea walls and revetments provide protection to existing shoreline development, these structures can contribute to erosion and accelerate beach loss. With ongoing beach erosion and sea-level rise and without any other mitigating measures, fixing the shoreline location with a sea wall or revetment will eventually lead to the loss of the beach seaward of the structure.

Moreover, using raised sea walls and revetments to "hold the line" on Oceanside's eroding shoreline with sea-level rise may not be sustainable due to increasing wave action and overtopping associated with the loss of the fronting beach. However, beach nourishment could be implemented in conjunction with a sea wall or revetment to at least partially offset this process. Additionally, the increased landward extent of wave action will require more frequent maintenance or reconstruction[2] of these structures, which can result in significant ongoing costs. Note that shoreline protection devices are designed to protect and withstand storm events up to a certain severity such as the 1% chance annual storm event. Storm events that are more severe than the design events can cause flooding and damage (see text box to the left). **Table 5-4** summarizes considerations for use of sea walls or revetments.

Additionally, revetments take up space on the beach and limit public access. During the summer in Oceanside, beach goers often cluster around breaks in the revetment where there is more space on the beach. Both sea walls and revetments can present public safety hazards, as well. There is a risk of people slipping and falling on revetments or having rocks topple on them. Erosion in front of sea walls has created drops that can be hazardous.

Shoreline protection device construction is regulated by the California Coastal Act (Coastal Act 30235) and the policies and regulations of the Oceanside LCP. The LCP allows for revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and similar construction that alters natural shoreline processes only when it is intended to serve coastal-dependent uses, to protect existing structures, or to protect public beaches in danger from erosion. When allowed, such devices must be designed to eliminate or mitigate impacts on local shoreline sand supply, minimize erosive impacts on adjacent unprotected property, and minimize encroachment on to the beach. The structures are not allowed to interfere with access along the beach. The LCP

[2] Permitting for sea wall or revetment maintenance is beyond the scope of this report, which is focused on long-term, high-level planning.

requires property owners to dedicate all area seaward of the shoreline structure for lateral access for the public. New development along the City's coastal bluffs and hillsides are not allowed if it would require the construction of protective devices that would substantially alter natural landforms. Obtaining permit approval for shoreline protection devices for any non-coastal dependent structures is a complex and lengthy process that, if successful, typically involves extensive mitigation measures, including mitigation fees. Recent storm damage to existing devices has resulted in multiple permit applications being submitted to the City's Permit Office for repair and maintenance approvals. The City is currently coordinating with the property owners and the CCC to clarify LCP requirements, permit procedural requirements, and City versus CCC permit jurisdiction. Although damage from storm events are anticipated to increase as a result of sea-level rise, this Adaptation Plan does not address the current complexities and challenges of allowing repair and maintenance to existing structures.

Table 5-4. Shoreline Protection Device Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$	▪ Commonly used engineering solution	▪ May require more frequent maintenance or reconstruction with sea-level rise
Environment	Major		▪ Accelerates beach erosion, since waves reflect off the structures and carry sand off the shore ▪ Impedes public access ▪ Degrades scenic qualities of coastal area ▪ "Holding the line" with walls will result in loss of the beach over time with sea-level rise
Flood Protection	Short-term	▪ Protects property and reduces flood and erosion risks for the design lifespan and conditions ▪ "Holds the line" and buys time to implement other adaptation strategies, like raising infrastructure or managed retreat	▪ Less effective over time with increasing sea levels
Timeline to Implement		▪ Properties with existing shoreline protection devices can seek permits for repair and maintenance	▪ New shoreline protection devices can involve complex permitting requirements.

5.3.4 Elevation of Structures and/or Property Grade

Examples of elevated development

Source: SPUR Report, 2011. https://www.spur.org/sites/default/files/publications_pdfs/SPUR_ClimateChangeHitsHome.pdf

Source: Copyright 2002-2016 Kenneth & Gabrielle Adelman, California Coastal Records project, www.californiacoastline.org

Raising Structures on Piles

Raising structures such as buildings, roads, and utilities is a measure that can remove infrastructure from coastal flooding elevations. Elevating structures can include raising buildings on pile foundations to allow for some limited migration and persistence of a fronting beach in the near-term (photo to the left). Raising roads and utilities could include replacing at-grade roads with pile-supported causeways. Associated utilities such as power, sewer, water, and electrical connections also need to be raised or waterproofed to avoid damage.

At some point when the tides are inundating the area, raising buildings on piles would be less feasible because access would be restricted (e.g., due to flooding of existing streets). Additionally, if measures such as beach and dune nourishment are not taken, the shoreline could continue to migrate past homes and potentially damage roads and infrastructure located inland, and even the raised buildings if the pilings are undermined. However, compared to maintaining sea walls or revetments, this option provides flexibility to retain structures while maintaining the beach.

For example, structures along the Strand could be raised to avoid damage from daily tidal inundation or coastal storm events. Access to the raised structures could no longer be from the Strand, but from Pacific Street, which is located inland of the structures. Changing access to these structures would have implications for Pacific Street Promenade, which currently has limited driveway cuts, and for properties that do not have frontage on Pacific Street.

Raising Grades

Raising buildings or roads could also be accomplished by placing fill to rebuild the grades at higher elevations. Utilities vulnerable to flooding, erosion, or increased ground water levels, such as sewer pipelines and storm drains often buried along roads, can also be raised, as long as gravity flow is maintained or pumps are installed. However, if one road is raised (e.g., the Strand) all connecting roads, trails, utilities, and structure access would have to be rebuilt to slope up to the new grade.

Floodable or Waterproofed Buildings

Building design/construction can also be modified so that the second floor is above the target flood level and contains all flood-sensitive features, while the first floor is used for parking and/or storage and is designed to be durable and resilient to flood damage. Abandoning the lowest floor or elevating the lowest habitable floor are effective in reducing damages to the buildings, and is a strategy often employed to meet Federal Emergency Management Agency (FEMA) base flood elevation minimums (**Figure 5-6**).

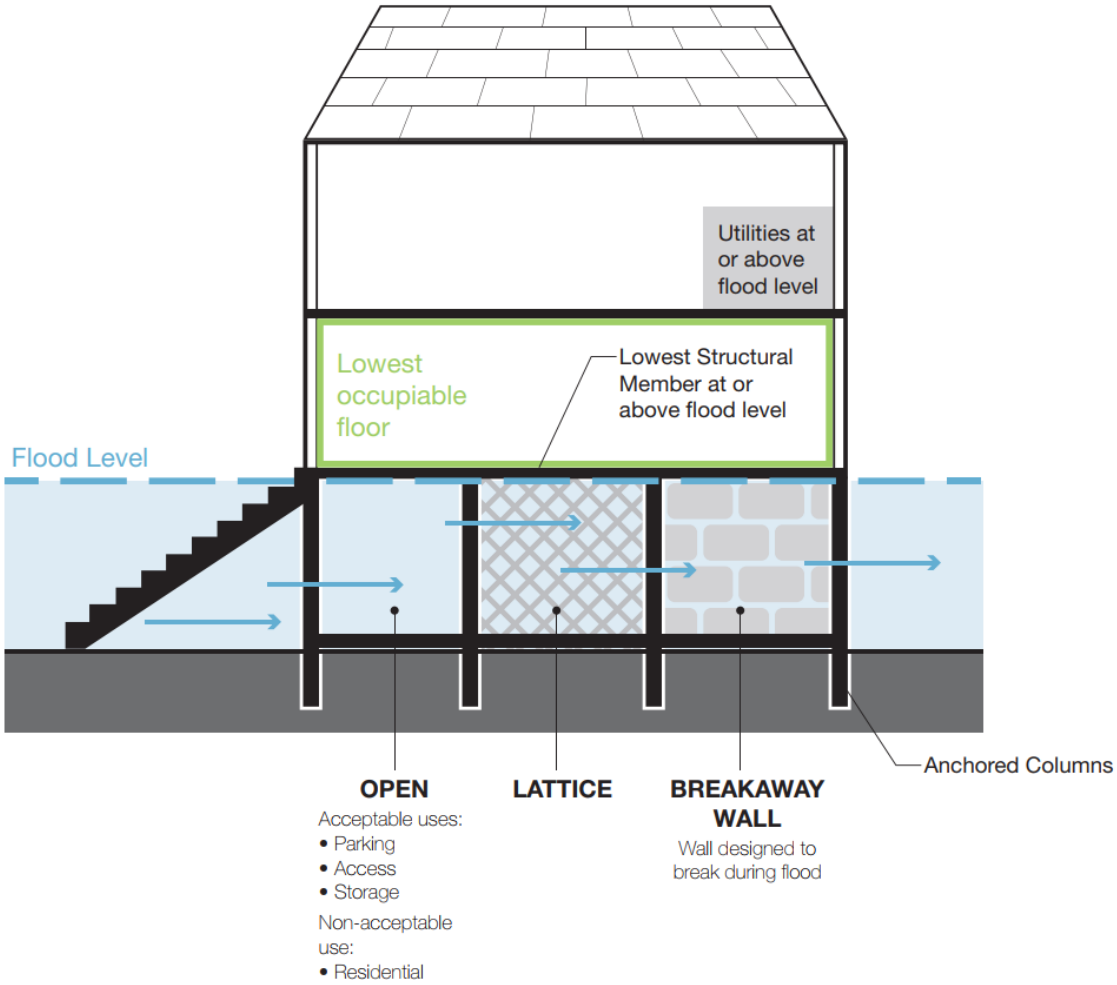


Figure 5-6. Schematic of floodable or waterproofed building

Policies and standards would need to be developed to address adaptive design. Retrofit requirements and the resulting loss of habitable or rentable space requires thoughtful consideration of height restrictions and other code requirements.

Table 5-5 summarizes the considerations for elevating structures and/or property grades and identifies the corresponding Guiding Principles.

5.3.5 Managed Retreat

Relocating or modifying the footprint of structures such as homes, buildings, roads, and utilities allows the shoreline to move inland, thereby maintaining the beach with sea-level rise. **Figure 5-7** illustrates how buildings and associated armoring (revetments or sea walls) can be removed from the coastal erosion and hazard zone. An active beach and dune shoreline can be restored with space for seasonal oscillation between beach erosion and accretion and progressive shoreline retreat over time with sea-level rise.

Table 5-5. Elevating Structures and/or Property Grade Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$	▪ Regional, state and federal funding sources may be available	▪ Elevating existing structures can be costly for the City and property owners
Environment	Benefit	▪ Maintains beach and allows for limited landward migration of beach	▪ Potential scenic, visual, and community character impacts
Flood Protection	Mid-term	▪ Removes structures from flood elevations	▪ Beach erosion and flooding will continue to migrate inland, requiring additional adaptation ▪ Must be implemented district-wide
Timeline to Implement		▪ Requires local permits only	▪ Need sufficient local guidance to navigate design and permitting requirements ▪ Would be implemented in mid- to long-term

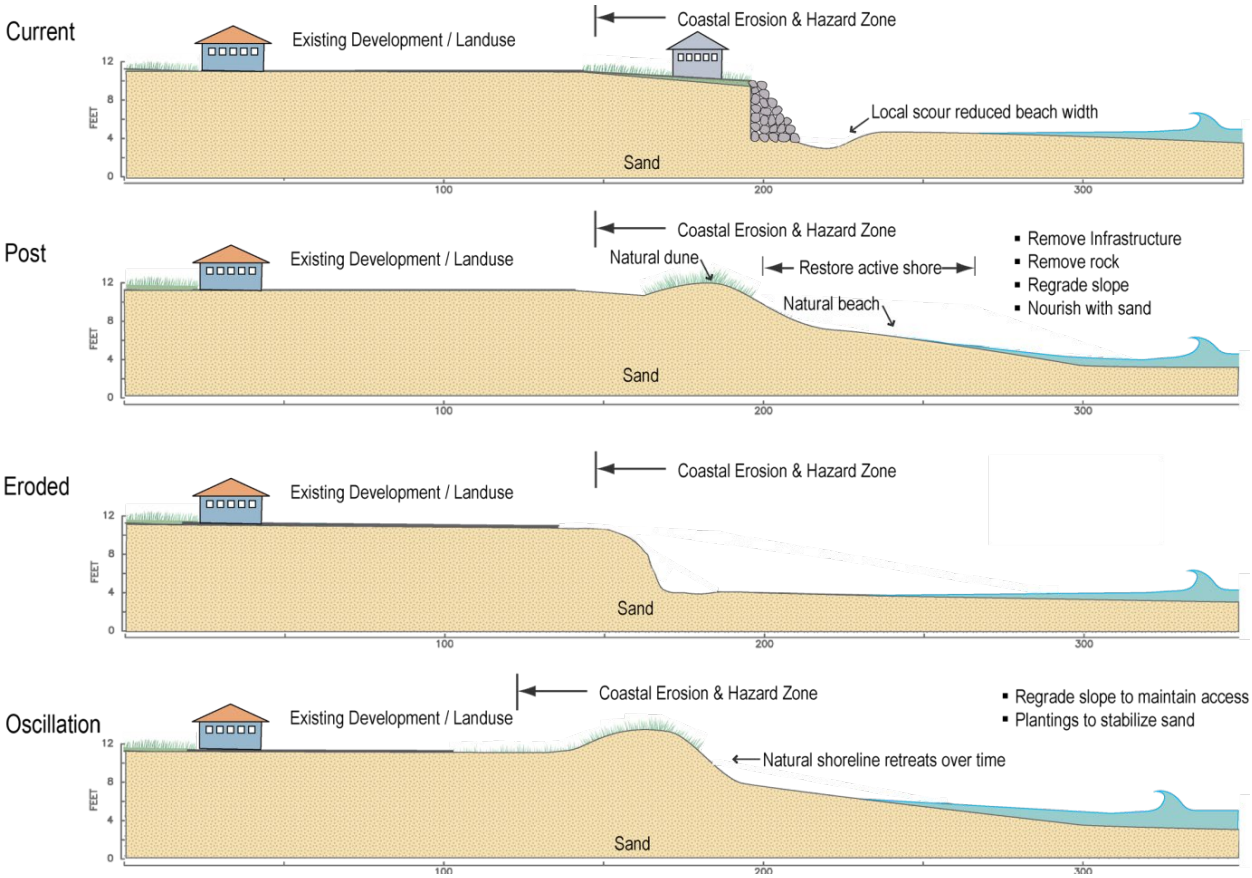


Figure 5-7. Illustration of managed retreat adaptation strategy

Although this may be the most straightforward method for adapting development that is under imminent or long-term threat of being damaged or destroyed, it is often assumed to be technically or financially infeasible. Often, there is not sufficient space or land available for the structure to be relocated to, and the property owner is responsible for the full cost of relocation. Accordingly, this approach has been most typically used for public property and by government agencies, which have applied it in Asilomar State Beach and Surfer's Point. In Oceanside, the City could allow managed retreat at Tyson Street Park.

The City can consider removal/relocation of public buildings, utilities, and other infrastructure as the risk to public facilities and operations increases with sea-level rise. For private property and development, the City could consider options for facilitating structure removal where there is a public benefit, such as removing structures to restore beach areas or parks that are resilient to flooding. Examples or models of local-government-led programs in California for coordinated removal of private property are limited. Additional state-wide policy, legal guidance, and funding mechanisms on such programs are likely needed to support the development of a private property removal program in Oceanside. The City can follow the development of removal or managed retreat programs and pursue studies of how such programs could be implemented in Oceanside. **Table 5-6** summarizes the considerations for managed retreat. Programs and policy options for removal or retreat are identified in Section 9, and include acquisition and buyout programs and rolling easements.

Table 5-6. Managed Retreat Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$$	▪ Avoided repeated costs for repair of storm and flooding damage ▪ Costs are low in places where no structures or infrastructure exist (e.g., parks)	▪ High costs due to high property values
Environmental Impact	Benefit	▪ Reduces the likelihood of damaged material entering the ocean and creating hazards elsewhere ▪ Allows for beach preservation and restoration and associated ecological and recreational resources	▪ Loss of recreational amenities ▪ Initial impacts to re-establish development elsewhere
Flood Protection	Long-term	▪ Removes at-risk development	
Timeline to Implement	🕓🕓🕓	▪ Would be sustainable in the long-term ▪ Requires local permits only	▪ Private property rights considerations ▪ Would require significant redevelopment of infrastructure ▪ Would be implemented in mid- to long-term

Programs and policy options for removal or retreat are identified in Section 9, and include acquisition and buyout programs, TDR programs, and rolling easements.

5.4 Coastal Flooding and Beach Erosion Adaptation Recommendations

Oceanside's extensive development and recreational amenities along the beach front are currently vulnerable to coastal storm flooding, wave impact, and beach erosion. The City has already implemented several strategies to reduce the risk of flooding and beach erosion, including beach nourishment and sand bypassing and sea walls and revetments along the coast.

Beach nourishment is likely preferable for as long as it is effective in order to enhance and maintain the existing assets and character of beach areas. Groins could potentially be pursued if or when beach and dune nourishment becomes less effective. As assets closest to the shore become more vulnerable, such as the Junior Seau Community Center, parking areas, the Strand, and residences, some combination of protecting, elevating, and managed retreat and realigning assets could be implemented.

In the near-term (e.g., before 1.6 feet of sea-level rise) the revetment/sea wall along the Strand could be maintained or improved and beach nourishment could be continued. This would provide property owners time to raise and/or flood-proof their homes, vacation rentals, and public property. Access would likely need to be shifted to Pacific Street. In the long-term (e.g., around 3.3 feet of sea-level rise), the Strand could be abandoned and utilities relocated.

South of the Strand, private revetments could be maintained or improved and properties and structures could be raised or flood proofed as overtopping of the revetment would increase with sea-level rise.

Table 5-7 summarizes the cost, environmental impact, flood protection, and timeline to implement each of these adaptation strategies.

Table 5-7. Beach and Coastal Flooding Adaptation Strategies Summary

Adaptation Strategy	Cost	Environmental Impact	Flood Protection	Timeline to Implement
Coastal Sediment Management	$$	Minor	Short-term	🕓🕓🕓
Sand Retention Structures	$$	Major	Short-term	🕓🕓🕓
Shoreline Protection Devices	$$	Major	Short-term	🕓🕓🕓
Elevate Structures	$$$	Benefit	Mid-term	🕓🕓🕓
Managed Retreat	$$$$	Benefit	Long-term	🕓🕓🕓

Section 6

RIVER AND CREEK FLOODING ADAPTATION

This section presents the vulnerability due to river and creek flooding in the low-lying areas of the city, monitoring to identify increasing risks, adaptation options to address the risk, and the recommended adaptation strategies for Oceanside.

6.1 Vulnerability of Low-Lying Areas to River and Creek Flooding

Oceanside is currently vulnerable to river and creek flooding. As described in Section 3 of the VA, extreme riverine flood events, which have caused significant damage, have occurred in Oceanside in 1916, 1939, 1940-41, 1969, 1978, 1980, 1983, 1991, 1993, 1995, and 1998 as well as more recent flooding.

The mouths of the San Luis Rey River, Buena Vista Lagoon, and Loma Alta Creek are expected to change in several ways in response to sea-level rise. The mouths of these river/creek systems are mostly closed by sand berms. (Note that the mouth of Buena Vista Lagoon is also closed off by a weir). These sand berms are naturally formed by waves, which push sand into the mouths. With higher sea levels, waves may push sand up to higher levels, causing the sand berms to rise in height. When rainfall and runoff cause high flows in the river/creek systems, the high flows can overtop and scour the sand berms, causing the mouths to open and flow directly to the ocean. The water levels in the river/creeks already overtop the banks and cause flooding during extreme events. The combination of higher sand berms and higher ocean water levels due to sea-level rise has the potential to increase flooding at the mouths of these systems during rain events.

Along the San Luis Rey River, increased flooding is expected along the San Luis Rey River trail and open space habitat areas within the coastal zone.

During larger storms, Loma Alta Creek currently floods the Oceanside RV Park, Paradise by the Sea RV Resort, La Salina Mobile Village, and Cavalier

Mobile Estates. Flooding during storms is expected to continue into the future, gradually increasing in frequency and affecting more properties near the creek.

At the Buena Vista Lagoon, the St Malo residential neighborhood is currently at risk of flooding during larger storms, and this risk would increase in the future.

Additionally, low-lying areas may experience increased flooding from rainfall runoff or wave overwash. Higher groundwater levels near the coast due to sea-level rise could limit how much water could infiltrate into the ground during a storm. Additionally, the stormwater system drains these areas to the ocean, but if the ocean water levels are higher due to sea-level rise, stormwater could back-up and increase flooding.

6.2 River and Creek Flooding Adaptation Monitoring

Factors to be monitored for low-lying riverine flood areas include sea-level rise, groundwater elevations, beach berm elevations at river/creek mouths, and river/creek flood levels and frequencies. Flooding from San Luis Rey River and Loma Alta Creek are already at the threshold of acceptable risk for the city and projects are planned or currently underway to reduce the risk of flooding (i.e., USACE planned dredging on the San Luis Rey River, flood retention basins currently under construction in the Loma Alta Slough watershed, and the Buena Vista Lagoon Enhancement project). The VA, which used the USGS CoSMoS results, shows extreme (i.e., 1% annual chance) coastal storm flooding[3] will increase with sea-level rise, but does not provide results showing how river and creek flooding during extreme rainfall runoff events will increase due to higher sea-levels at the creek mouths. In order to develop monitoring and adaptation triggers for river and creek flooding, acceptable levels of risk could be established for each river and creek for existing conditions or as part of current project designs. Extreme river and creek flood levels, frequencies, and channel capacities could be modeled for baseline conditions and with future projected sea-level rise.[4] The amount of sea-level rise that exceeds the acceptable level of flood risk could be estimated as a trigger.

Groundwater levels should also be considered for systems that rely on flood storage. As an example, **Figure 6-1** shows a conceptual channel cross-section where a 10% annual chance storm event in the channel is considered an acceptable level of flood management or risk (e.g., the storm event does not cause flooding). Sea-level rise is shown as increasing the groundwater to the

[3] Note that CoSMoS' extreme coastal storm flooding scenario includes flooding due to rainfall runoff and creek flows that are estimated to occur coincidentally with an extreme coastal storm; however, the estimated coincident creek flows are less than an extreme (i.e., 1% annual chance) rainfall runoff/creek flood event.

[4] Note that modeling studies of extreme river and creek flood levels with sea-level rise have not been performed by USGS or FEMA.

point where the channel water level during a 10% annual chance event approaches the top of the channel. This amount of sea-level rise represents a trigger for adaptation, as further increases in sea-level rise would be likely to cause flooding during a 10% annual chance event.

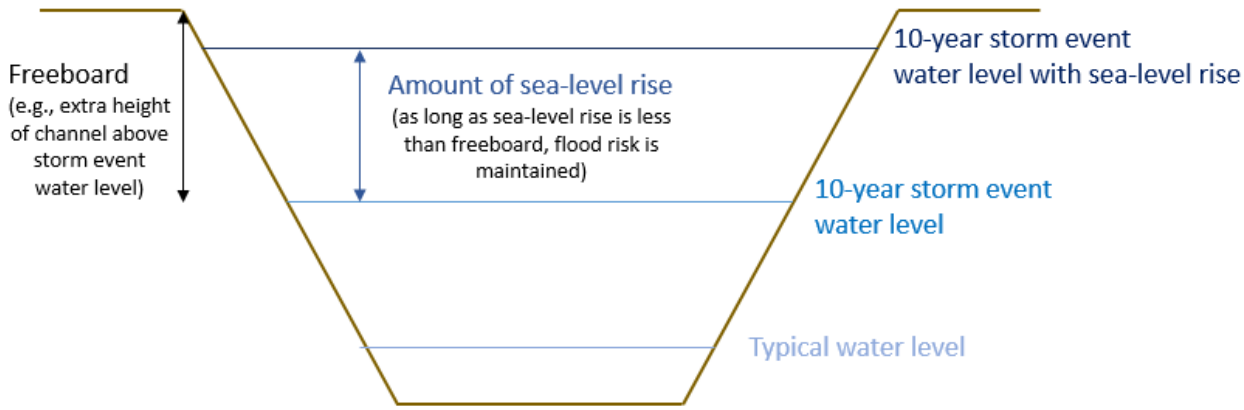


Figure 6-1. Illustration of theoretical channel freeboard

Potential triggers for the river and creeks are listed below. Further assessment is recommended to refine and confirm these triggers.

- Groundwater levels increase to a point that the normal river and creek water levels supported by groundwater approach levels that present an unacceptable flood risk. Monitoring the increase groundwater and river and creek water levels could therefore be used to assess this trigger for adaptation, such as groundwater pumping; however, the feasibility of lowering groundwater levels to managed river and creek water levels requires further assessment and other/additional adaptation strategies are expected be required with this amount of sea-level rise.
- If the beach and lagoons are maintained via sand management and or other adaptation strategies with sea-level rise, the beach and sand berm are expected to increase in elevation along with sea-level rise. This would increase the lagoon water levels and compromise flood management. The increase in the elevation of the beach berm could therefore be monitored as a trigger for adaptation.

6.3 River and Creek Flooding Adaptation Options

Possible adaptation strategies for river and creek flooding include:

- River and creek channel management (e.g., dredging, mouth maintenance)
- Groundwater pumping
- Flood detention basins
- River and creek flood walls or levees with wetland restoration
- Elevation of structures and/or property grades

The mouth of the Los Peñasquitos Lagoon in San Diego is regularly dredged to maintain an open tidal connection with the ocean.

- Managed retreat

6.3.1 River and Creek Channel Management

River and creek channel management could involve dredging certain areas along the channel or managing the mouth/inlet of the river or creek. Additionally, this could include management of the weir at Buena Vista Lagoon.

Dredging

The purpose of channel dredging is to maintain a channel bed near its current elevation and maintain the river flood risk near the current risk level. This could be accomplished using marine-based floating dredges and barges and/or land-based equipment operated from the channel bank. Assuming the dredged material is primarily sand, the dredged material could be placed on the beach to provide nourishment as a beach adaptation measure.

The proposed USACE San Luis Rey River flood protection project would deepen the channel and expand the river capacity through the removal of 210,000 cy of sediment along a one-mile stretch between Benet Road and Foussat Road, which is upstream of the Coastal Zone. The project was authorized by Congress in 1970 as part of the Flood Control Act of 1965 (USACE 2014) but has yet to be implemented.

As part of the Adaptation Plan, it is recommended that the City review any available San Luis Rey River channel survey data and deposition monitoring and communicate with USACE on the channel dredging project to effectively reduce flood risk for Oceanside properties. The City should coordinate with USACE to identify optimal times and placements for dredged riverbed material on the Oceanside beaches, such that dredged material would remain in place on the beach for as long as possible.

Dredging may not be effective at lowering flood risk for the Buena Vista Lagoon and Loma Alta Slough because deepening areas that are currently ponded would not likely provide added flood storage or capacity and would likely have substantial environmental impacts. Expanding the lagoon wetland areas through restoration could be effective at lowering flood risk. **Table 6-1** summarizes considerations for channel dredging.

Mouth Maintenance

Loma Alta Creek and San Luis Rey River

The City could consider managing the mouth of the Loma Alta Slough or the San Luis Rey River to reduce flooding. This could include beach grooming to lower the beach berm prior to a major storm event, which would allow the slough/river to breach a little earlier, resulting in lower water levels in the channel.

Table 6-1. Channel Dredging Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$	▪ Cost sharing with USACE may be available	▪ Off-site disposal of dredged material can be costly ▪ Requires increased management
Environmental Impact	Major	▪ Dredged material could be used for beach nourishment or other sediment-starved areas as part of a regional sediment management plan	▪ Ecology impacts to in-water habitat
Flood Protection	Mid-term	▪ Maintains the river flood risk near the current risk-level	▪ Requires frequent and continued management
Timeline to Implement	🕓🕓🕓	▪ Dredging San Luis Rey River has already been authorized by Congress	▪ Requires substantial planning and permitting

Buena Vista Creek

The Buena Vista Lagoon Enhancement project is a project that is analyzing multiple alternatives for lagoon enhancement, with the goals of improving lagoon ecological and recreational values. As part of the EIR, finalized in September 2017, flood modeling was conducted to analyze impacts from the project. The modeling results showed that all of the alternatives reduced flood levels at the mouth of the lagoon under current conditions and with sea-level rise (Everest 2014).

The project includes four alternatives:

1. **Freshwater Alternative**, which would include vegetation management in the lagoon and dredging. The weir at the mouth of the lagoon would be replaced with a wider, 80-foot weir.
2. **Saltwater Alternative**, which would remove the weir at the mouth of the lagoon and allow full tidal flow into the system through a confined tidal inlet.
3. **Hybrid Alternative, Option A**, which would remove the weir at the mouth of the lagoon to allow tidal flow into a confined tidal channel. The channel would go through the first basin and only allow high tide flooding beyond the channel. This option would also install a new weir under the I-5 bridge to maintain the freshwater hydrologic regime east of the I-5.
4. **Hybrid Alternative, Option B**, which would remove the weir at the mouth of the lagoon to allow full tidal flow into the first basin through a confined tidal channel, and install a new weir under the I-5 bridge to maintain the freshwater hydrologic regime east of the I-5.

Table 6-2 presents the flood reductions for each alternative based on the modeling results.

Table 6-2. Flood Reduction Benefits for Buena Vista Lagoon Enhancement Project Alternatives During a 100-yr Storm Event

Sea-Level Conditions	Alternative	Flood Reduction Compared to Existing Conditions (feet)
2015	Freshwater Alternative	0.4 – 2.5
	Saltwater Alternative	4.4 – 7.6
	Hybrid Alternative	0 – 5.5
2050	Freshwater Alternative	1.5 – 3.1
	Saltwater Alternative	4.6 – 8.1
	Hybrid Alternative	0.9 – 5.6
2100	Freshwater Alternative	1.6 – 3.1
	Saltwater Alternative	2.9 – 6.2
	Hybrid Alternative	1.0 – 4.0

Source: Everest 2014

As of the SANDAG Board of Directors meeting on November 16, 2018, the project has been delayed for six months to allow residents to reach a consensus on the enhancement efforts. Implementing one of the alternatives from the Enhancement Project could be an adaptation strategy to address increased flooding along the Buena Vista Lagoon with sea-level rise.

Table 6-3 summarizes considerations for channel mouth maintenance.

Table 6-3. Channel Mouth Maintenance Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$	▪ One-time cost to remove or improve the weir at the mouth of Buena Vista Lagoon	▪ Beach grooming at creek mouths would increase maintenance costs
Environmental Impact	Minor	▪ Environmental impacts have already been evaluated and mitigated for in the Buena Vista Lagoon Enhancement Project EIR	▪ Potential impacts to beach use and habitat
Flood Protection	Mid-term	▪ Lowering the beach berm at creek mouths could lower creek flood levels ▪ Removing or improving the weir at Buena Vista Lagoon would lower lagoon flood levels	▪ Weirs (if left in place or improved at Buena Vista Lagoon) would become less effective over time with increasing sea-level rise
Timeline to Implement		▪ The Buena Vista Lagoon Enhancement Project EIR has already been prepared and the project is under development	▪ Beach grooming for creek mouths could require substantial planning and permitting

6.3.2 Groundwater Pumping

As sea levels rise, groundwater elevations are expected to rise and may result in flooding, impacts to the structural integrity of infrastructure, or groundwater intrusion into pipes. Using pumps to lower the groundwater table is an adaptation strategy that could reduce these risks. Once the groundwater reaches a certain elevation, underground dewatering wells and pumps could be installed to lower groundwater and discharge it to the stormwater system. This would require additional conveyance pipes and outfalls to manage the higher pumping rate.

Groundwater pumping would first be required in low-lying areas with below ground assets, such as parking or basements. Eventually, dewatering wells may need to be spread across the low-lying areas to achieve a lowered groundwater table.

The feasibility of maintaining a lowered groundwater table through pumping is outside the scope of this Adaptation Plan and would need to be further assessed. Discharge of the pumped groundwater (e.g., to the storm drain, wastewater system, or a surface water body) and any water quality treatment considerations are beyond the scope of this plan. **Table 6-4** summarizes the considerations for groundwater pumping.

Table 6-4. Groundwater Pumping Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$		▪ On-going operations and maintenance costs ▪ May require more frequent maintenance or reconstruction with increased sea-level rise
Environmental Impact	Minor		▪ Alters groundwater flow regimes, which can have physical, chemical, and biological impacts
Flood Protection	Long-term	▪ Expected to be effective up to about 2 to 6 feet sea-level rise	▪ Less effective over time with increasing sea-level rise ▪ Pumping would need to increase over time with sea-level rise
Timeline to Implement	🕒🕒🕒	▪ Local permits only	▪ The feasibility of maintaining a lowered groundwater table through pumping requires further assessment

6.3.3 Flood Detention Basins

In order to reduce flood flows on the river and creeks, large flood detention basins could be constructed to provide flood storage during storms. This would require below-grade construction and easements or vacant City-owned land.

The City is in the process of planning and constructing three flood basins along Loma Alta Creek as part of the Loma Alta Creek Flood Control Improvement Project. The first basin, along Garrison Creek at the southeast corner of Mesa Drive and El Camino Real outside of the coastal zone was completed in 2006. The second basin, along Loma Alta Creek at El Camino Real outside of the coastal zone, has also been constructed. A third basin along Loma Alta Creek at Rancho Del Oro Drive outside of the coastal zone is still in the planning phase. It is expected that these basins will help reduce riverine flooding along the Loma Alta Creek, including areas downstream of the basins and within the coastal zone. **Table 6-5** summarizes the considerations for flood detention basins.

Table 6-5. Flood Detention Basins Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$		▪ On-going operations and maintenance costs
Environmental Impact	Major		▪ Excavation and grading impacts to create basins
Flood Protection	Long-term	▪ Continued reduction of riverine flooding in the upper watershed regardless of sea-level rise	▪ Flooding at the mouth will continue to increase with sea-level rise
Timeline to Implement		▪ Local permits may only be required ▪ Some basins have already been constructed	

6.3.4 River and Creek Flood Walls or Levees with Wetland Restoration

The City could consider the use of flood walls or levees as an adaptation strategy along the river and creeks, in addition to sea walls or revetments for coastal waterfront property (see Section 5.3.3 Shoreline Protection Devices). The purpose of the river and creek flood management structures would be to limit flooding of low-lying areas due to ocean water levels filling and overtopping the channels with sea-level rise. Additionally, flood walls or levees would also address increased river and creek flood levels during rainfall runoff events due to sea-level rise at the mouths of the channel. Flood walls or levees could connect with shoreline protection devices along the coastline. River and creek protection devices would likely need to be paired with pump stations to convey stormwater that would typically drain directly to the creeks from the backside of the flood wall or levee.

The San Luis Rey River has an existing levee system along the 7 miles of the river closest to the coast, which was built and is maintained by the USACE. This system could be improved (e.g., levee heights increased) or expanded upstream as sea-level rise increases. If and where space allows, the levees

could be designed as "living levees" by creating gently-sloping upland, transition, and vegetated habitats between the levee and the river (**Figure 6-2**). This approach is being adopted in wetland restoration practice to enhance habitat diversity and provide wetland buffers and high water refuge.

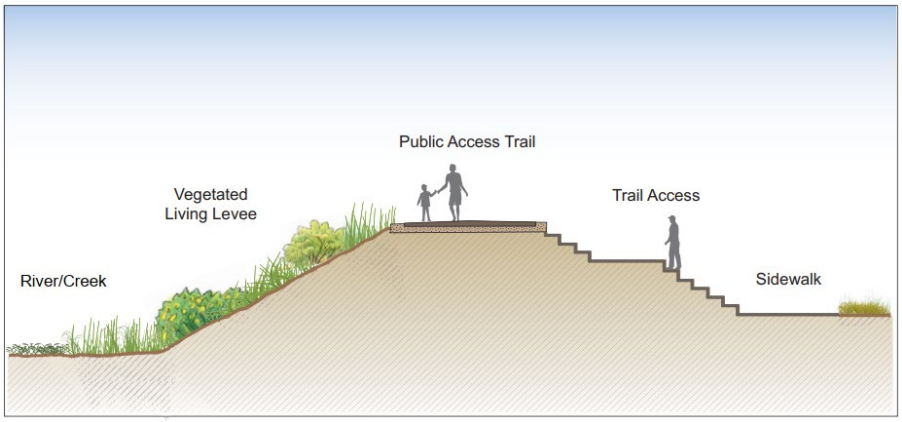


Figure 6-2. Example levee cross-section with public access

Soil for levee construction would need to meet specific engineering criteria and may need to be imported from off-site. The levees would need to be planned and designed to reduce potential impacts to existing habitats and flood levels upstream.

In certain areas, such as along Loma Alta Creek or Buena Vista Lagoon, there may not be sufficient room for a levee system and flood walls may be more appropriate. **Table 6-6** summarizes the considerations for river and creek protection devices.

6.3.5 Elevation of Structures and/or Property Grades

As discussed in Section 5.3.4, raising structures such as buildings, roads, and utilities is a measure that could reduce the impacts of riverine flooding. Elevating structures can include raising buildings on pile foundations, raising grades, or designing structures to be floodable or waterproof.

Table 6-7 summarizes the considerations for elevating structures. See Section 5.3.4 for a more detailed discussion.

Table 6-6. Flood Walls or Levees with Wetland Restoration Considerations

Consideration	Scoring	Benefits	Constraint
Cost	$$$		▪ Could require substantial fill material which would increase costs ▪ Flood walls are expensive
Environmental Impact	Major	▪ Can provide some wetland habitat ▪ Can provide co-benefits, including carbon sequestration	▪ Could require a large right-of-way, which could have major ecological impacts during construction ▪ Potentially impedes public access to creeks and river
Flood Protection	Mid-Term	▪ Reduces flooding	▪ Less effective over time with increasing sea levels
Timeline to Implement			▪ Requires substantial planning and permitting ▪ San Luis Rey river is regulated by the USACE

Table 6-7. Elevating Structures Considerations

Consideration	Scoring	Benefits	Constraint
Cost	$$$	▪ Regional, state and federal funding sources may be available	▪ Elevating existing structures can be costly for the City and property owners
Environment	Benefit		▪ Could change visual character ▪ Could impact views
Flood Protection	Mid-term	▪ Removes structures from flood elevations	▪ Flooding could continue to migrate inland, requiring additional adaptation ▪ Must be implemented district-wide across neighborhoods or else raising some structures could cause increased flooding of other structures
Timeline to Implement	[1]	▪ Raising structures would not involve work in the water or on the beach ▪ Requires local permits only	▪ Need sufficient local guidance to navigate design and permitting requirements

1. *Raising individual structures could be a relatively quick process, but raising an entire area as individual structures are (re-)developed would be on a longer timeline.*

6.3.6 Managed Retreat

As discussed in Section 5.3.5, the City can consider removal of buildings, utilities, and other infrastructure in low-lying, flood-prone areas as the flood

risk increases with sea-level rise. The decommissioning of the La Salina Wastewater Treatment Plant along Loma Alta Creek has the added benefit of removing infrastructure out of a flood hazard area. **Table 6-8** summarizes the considerations for managed retreat. See Section 5.3.5 for a more detailed discussion.

Table 6-8. Managed Retreat Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$$	▪ Avoids repeated costs for repair of storm and flooding damage ▪ Costs are low in places where no structures or infrastructure exist (e.g., parks)	▪ Property acquisition could be expensive
Environmental Impact	Benefit	▪ Reduces likelihood of damaged material entering the river/creek system and creating hazards elsewhere ▪ Allows for restoration and associated ecological and recreational resources	▪ Initial impacts to re-establish development elsewhere
Flood Protection	Long-term	▪ Removes at-risk development	
Timeline to Implement	🕓🕓🕓	▪ Would be sustainable in the long-term ▪ Requires local permits only	▪ Private property rights considerations ▪ Would require significant redevelopment of infrastructure

6.4 River and Creek Flooding Adaptation Recommendations

Oceanside's extensive development along the rivers and creeks is currently vulnerable to riverine storm flooding. The City has already implemented or is in the process of developing several adaptation strategies to reduce the risk of flooding, including USACE dredging along the San Luis Rey River, the Buena Vista Lagoon Enhancement project, flood detention basins along Loma Alta Creek, levees along the San Luis Rey River, and removal of the La Salina Wastewater Treatment Plant.

River and creek channel management is likely preferable as long as it is effective and flood detention basins and river levees have already been constructed. Groundwater pumping could potentially be pursued if or when groundwater is impacting development, but more studies are needed. In the long-term, elevating or removing structures may be needed to remove development from flood areas.

Table 6-9 summarizes the cost, environmental impact, flood protection, and timeline to implement each of these adaptation strategies.

Table 6-9. River and Creek Flooding Adaptation Strategies Summary

Adaptation Strategy	Cost	Environmental Impact	Flood Protection	Timeline to Implement
Channel Dredging	$$	Major	Mid-term	
Mouth Maintenance	$$	Minor	Mid-term	
Groundwater Pumping	$$$	Minor	Long-term	
Flood Detention Basins	$$	Major	Long-term	
Levees with Wetlands Restoration	$$$	Major	Mid-term	
Elevate Structures	$$$	Benefit	Mid-term	
Managed Retreat	$$$$	Benefit	Long-term	

Section 7

HARBOR AND PIER FLOODING ADAPTATION

One of Oceanside's coastal amenities unique to north coastal San Diego County is the Harbor, a tourist attraction that includes a marina, boat docks, boat slips, launching ramps, fishing pier, Harbor Village which hosts retail shops and restaurants, multiple parking lots, and overnight lodging, as well as one of San Diego's widest beach. The Pier is one of the longest wooden piers on the west coast, and serves as a backdrop for some of Oceanside's most popular events. The Pier and Harbor are iconic landmarks along the city's coastline and play an important role in Oceanside's local and tourist economy.

This section presents the vulnerability due to coastal flooding at the Harbor and Pier, monitoring to identify increasing risks, adaptation options to address the risk, and the recommended adaptation strategies for Oceanside.

7.1 Vulnerability of the Harbor and Pier to Coastal Flooding

Roughly 80% of the Harbor, including restaurants, parking lots, and Harbor Drive, is currently at risk for flooding from a large coastal storm event. With sea-level rise, the area at risk of flooding and the frequency of large storms is expected to increase. Daily tidal flooding could reach the parking lots, restaurants, and parts of Harbor Drive by 2040. Regular flooding of the Harbor could impact docks, roads, and buildings and would likely result in a significant economic impact to the city. Regular flooding would also result in a loss of access and recreation.

As sea levels continue to rise, daily flooding from high tide will impact more businesses and more portions of Harbor Drive, so that by 2100, assuming the City does nothing, the Harbor could become completely inaccessible, with all the parking lots and restaurants flooded on a daily basis and the hotels either flooded or impossible to reach.

Under existing conditions, the Pier is exposed to wave damage during large storms, and a 1% annual chance coastal event is expected to require temporary closure and significant structural repairs. As sea level rises, events

large enough to damage the Pier are expected to become more common. Tidal conditions are not likely to pose a risk of damage for the pier deck.

7.2 Harbor and Pier Flooding Adaptation Monitoring

The criteria to be monitored for the Harbor and Pier is sea-level rise and flooding frequency. The VA showed that minor impacts that are already occurring in the Harbor today are expected to get worse with sea-level rise. While further analysis is needed, the sea-level rise approaching 0.8 feet of sea-level rise can be considered for a planning trigger.

7.3 Harbor and Pier Flooding Adaptation Options

Possible adaptations for flooding, erosion, and damage of the Harbor and Pier include:

- Raising and/or modifying the Harbor breakwater
- Raising the marina facilities
- Raising the Pier
- Managed retreat
- Abandoning the Harbor
- Abandoning the Pier

A sea wall could be added to the Oceanside Harbor breakwater to offset the increase in flood levels with sea-level rise.

7.3.1 Raising and/or Modifying the Harbor Breakwater

As discussed in Section 5.3.2, breakwaters are structures constructed parallel to the shore that reduce wave action. The breakwater at the Oceanside Harbor reduces waves in the Harbor and protects the Harbor from large storm events. With sea-level rise, it is expected that the breakwater will be overtopped more frequently and provide less protection for the Harbor.

The existing breakwater (**Figure 7-1**) could be raised and improved to offset the increase in flood levels with sea-level rise. This could be accomplished by adding a new section of rock to the top of the existing breakwater or by adding a parapet wall (see text box to the left). If the breakwater is raised, the public path on top of the breakwater would require modification or reconstruction to maintain access.

Table 7-1 summarizes the considerations for raising or modifying the Harbor breakwater. See Section 5.3.2 (Sand Retention Structures) for a more detailed discussion.

Source: Google Maps Street View, Eric Young, March 2016

Figure 7-1. Existing Oceanside Harbor breakwater

Table 7-1. Raising the Breakwater Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$	▪ One-time implementation costs	▪ In-water work is more costly ▪ Structure may need to be rebuilt or significantly modified to support increased height
Environment	Major		▪ An expanded breakwater footprint would have ecological impacts ▪ Could change visual character
Flood Protection	Short-term	▪ Shelters the Harbor by causing waves to break and limiting waves from entering the Harbor	▪ Less effective over time with increasing sea levels ▪ Structure will continue to experience damage from storm events
Timeline to Implement			▪ Complex permitting requirements from state and federal agencies

7.3.2 Raising the Marina Facilities

As discussed in Sections 5.3.4 and 6.3.4, raising structures such as buildings, roads, and utilities is a measure that could reduce the impacts of coastal flooding. Elevating structures can include raising buildings on pile foundations, raising grades, or designing structures to be floodable or waterproof.

Guide piles allow docks and other floating infrastructure to move up and down with changing water levels. They are typically stiff enough to keep infrastructure in place but flexible enough to absorb heavy wave action.

Source: Harbor Technologies, www.harbortech.us/guide-piles

Facilities within the marina, such as docks and other floating infrastructure could be reconstructed with longer guide piles and support piles (see text box to the left) to allow infrastructure to float higher with higher water levels.

The City could raise the grades of Harbor Village, including the parking lots (see Section 5.3.4 for additional discussion). Fill could be imported, if testing indicates the material is appropriate. Bulkheads may also be used on the inside of the Harbor to retain the imported fill to maintain the same parking area.

Buildings and roads adjacent to the Harbor, such as Harbor Drive, could be raised, for example by placing fill and rebuilding buildings and roads at higher elevations. Alternatively, raising grades around the Harbor could protect adjacent areas from flooding, with sloping transitions from raised Harbor areas to adjacent infrastructure.

Table 7-2 summarizes the considerations for raising the marina facilities. See Section 5.3.4 for a more detailed discussion.

Table 7-2. Raising the Marina Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$	▪ Costs for flood protection would be reduced	▪ Elevating existing structures can be costly
Environmental Impact	Minor	▪ Extends recreational benefits	▪ Short-term impacts during construction ▪ Could change visual character ▪ Raising structures would involve work in the water or on the beach
Flood Protection	Mid-term	▪ Removes structures from flood elevations ▪ Increases marina facilities' resiliency to storm events	▪ Less effective over time with increasing sea levels
Timeline to Implement	🕓🕓🕓	▪ As structures are rebuilt, there will be more opportunities to rebuild in a way that adapts to sea-level rise	▪ Complex permitting requirements from state and federal agencies ▪ Could require agreement between the City and tenants. The level of consensus needed is difficult to achieve.

7.3.3 Raising the Pier

Adaptation of the Pier would consist of reconstructing the Pier with a higher deck and deck structural support members. Reconstruction may need to occur more than once over the forecasted 100-year period. An alternative would be to design the reconstruction to accommodate structural modification consisting of raising the deck to accommodate higher sea levels, although

assessing the feasibility of this approach is beyond the scope of this Adaptation Plan. **Table 7-3** summarizes the considerations for raising the Pier. See Section 5.3.4 for a more detailed discussion.

Table 7-3. Raising the Pier Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$	▪ Reduces maintenance and repair costs, reduces the likelihood of Pier closures, which can impact local businesses	▪ Elevating the Pier could be costly for the City ▪ Reconstruction may need to occur more than once as sea levels continue to rise
Environmental Impact	Minor	▪ Extends recreational benefits	▪ Could change visual character ▪ Ecological impacts from reconstruction
Flood Protection	Long-term	▪ Removes structures on Pier from flood elevations	▪ Structure will continue to experience damage from storm events, which will likely increase in intensity and frequency in the future
Timeline to Implement	🕓🕓🕓		▪ Complex permitting requirements ▪ Raising structures would involve work in the water and on the beach

7.3.4 Managed Retreat

As discussed in Sections 5.3.5 and 6.3.5, the City can consider the removal and relocation of buildings, utilities, and other infrastructure in the Harbor area as the risk to structures increases with sea-level rise. **Table 7-4** summarizes the considerations for managed retreat and identifies. See Section 5.3.5 for a more detailed discussion.

7.3.5 Abandoning the Harbor

In the future, when flooding becomes frequent and unmanageable, the Oceanside Harbor could be abandoned and removed. The area could be restored to provide coastal habitat, and if the Camp Pendleton Boat Basin was also abandoned, the natural coastal sediment processes could be restored to the Oceanside Littoral Cell.[5] Without additional adaptation strategies, abandoning the Harbor and the breakwater could increase flood risks to Harbor Drive and the development to the east. Significant analysis would be needed to understand how hazards would change with the loss of the Harbor

[5] The Oceanside Littoral Cell, which spans approximately 57 miles from Dana Point to Point La Jolla, is a coastal compartment that contains a complete cycle of sedimentation including sources (e.g., San Luis Rey river), transport paths, and sinks (e.g., the La Jolla Submarine Canyon).

and breakwater and how the beaches in the area would respond. **Table 7-5** summarizes the considerations for abandoning the Harbor.

Table 7-4. Managed Retreat Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$$	▪ Avoided repeated costs for repair of storm and flooding damage	▪ High costs due to high property values and lost revenue
Environmental Impact	Benefit	▪ Reduces likelihood of damaged material entering the ocean and creating hazards elsewhere ▪ Allows for beach preservation and restoration and associated ecological and recreational resources	▪ Initial impacts to re-establish development elsewhere
Flood Protection	Long-term	▪ Removes at-risk development	
Timeline to Implement	🕓🕓🕓	▪ Would be sustainable in the long-term	▪ Private property rights considerations ▪ Would require significant redevelopment of infrastructure

Table 7-5. Abandoning the Harbor Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$$$	▪ Avoids repeated costs for repair of storm and flooding damage	▪ High costs due to high property values and lost revenue
Environment	Benefit	▪ Could restore natural sand transport from the north ▪ Could provide coastal habitat ▪ Allows for landward migration of beach	
Flood Protection	Long-term	▪ Removes at-risk development ▪ Restored natural transport could help preserve beaches down coast	▪ Erosion and flooding will continue to migrate inland, requiring additional adaptation
Timeline to Implement	🕓🕓🕓	▪ Would be sustainable in the long-term	▪ Complex permitting requirements ▪ Would require extensive coordination with Camp Pendleton

7.3.6 Abandoning the Pier

In the future, when storm impacts become frequent and unmanageable, the Pier could be abandoned and removed. Significant analysis would be needed to understand how the beaches in the area would respond. **Table 7-6** summarizes the considerations for abandoning the Pier.

Table 7-6. Abandoning the Pier Considerations

Consideration	Scoring	Benefits	Constraints
Cost	$$	▪ Avoids repeated costs for repair of storm and flooding damage	▪ Lost revenue
Environment	Benefit	▪ Could restore natural sand transport from the north ▪ Could provide coastal habitat ▪ Allows for landward migration	▪ Loss of public access and recreation
Flood Protection	Long-term	▪ Removes at-risk development ▪ Restored natural transport could help preserve beaches down coast	▪ Erosion and flooding will continue to migrate inland, requiring additional adaptation
Timeline to Implement	🕒🕒🕒	▪ Would be sustainable in the long-term	▪ Complex permitting requirements

7.4 Harbor and Pier Flooding Adaptation Recommendations

Oceanside's extensive development in the Harbor and the Pier is currently vulnerable to coastal storm flooding and wave impact.

Initially, the Harbor breakwater and marina facilities could be raised. With more time, the grade around the Harbor could also be raised to protect the roads and structures. In the mid-term, the Pier could be raised.

Table 7-7 summarizes the cost, environmental impact, flood protection, and timeline to implement of each of these adaptation strategies.

Table 7-7. Harbor and Pier Flooding Adaptation Strategies Summary

Adaptation Strategy	Cost	Environmental Impact	Flood Protection	Timeline to Implement
Raising and/or Modifying the Breakwater	$$$	Major	Short-term	
Raising the Marina	$$$	Minor	Mid-term	
Raising the Pier	$$$	Minor	Long-term	
Managed Retreat	$$$$	Benefit	Long-term	
Abandoning the Harbor	$$$$	Benefit	Long-term	
Abandoning the Pier	$$	Benefit	Long-term	

Section 8

POTENTIAL ADAPTATION SCENARIO ANALYSIS

This Adaptation Plan identifies a range of adaptation strategies that the City could take in the future to reduce risks associated with sea-level rise. The Adaptation Plan allows the flexibility for the City to select and implement specific adaptation strategies as the effects of sea-level rise reach certain triggers based on City policy decisions and adaptation project specific planning.

This section includes a case study of a potential adaptation scenario that the City and its residents could undertake to respond to sea-level rise and associated erosion and flooding vulnerabilities to coastal areas and assets. The analysis of this potential scenario is intended to provide quantitative engineering and economic cost and benefit information to inform the Adaptation Plan and City. The estimated cost and benefit information for the potential scenario provides an indication of the possible future costs and benefits of adaptation and a basis for the City to plan for implementing the Adaptation Plan in the future. The potential adaptation scenario is not intended to indicate the City's proposed or preferred approach to adaptation. Actual implementation of adaptation by the City will differ from this scenario and cannot be prescribed at present; actual adaptation will be dependent on monitoring towards adaptation triggers and future City policy decisions.

The potential scenario described and analyzed below was developed in coordination with City staff and modeled through time by estimating the engineering costs associated with individual adaptation strategies and modifying the hazard exposure maps to reflect reductions in hazard exposure and/or modification of existing development. The estimated costs to implement the scenario and associated changes in hazard exposures are compared to the costs/damages of the "do-nothing" scenario associated with the VA. This planning level estimate of costs and benefits are approximate and are based on assumptions that address uncertainties. The cost/benefit estimate is intended to provide a comparison between adaptation and "do-nothing" scenarios, quantitatively show the benefits of adaptation, and indicate a rough estimate of potential future City funding needs. Key assumptions and considerations are described along with results of the cost benefit analysis (see Appendix A for more information on the cost benefit analysis).

8.1 Adaptation Scenario Description

One adaptation scenario was developed to compare to the "do nothing" scenario. The adaptation scenario can be described in terms of three areas along the City's waterfront: the Harbor, the Strand (San Luis Rey River to Wisconsin Ave), and remaining south coast (Wisconsin Ave to Buena Vista Lagoon). The adaptation scenario is comprised of multiple adaptation strategies specific to each area that avoid or reduce coastal hazards identified in the VA.

8.1.1 Harbor

Adaptation in the Harbor focuses on avoiding rising tides and storm surge, but also includes beach nourishment. To avoid damages from storm surge, new and upgraded bulkheads would be built in the near term and expanded and maintained in the long-term to accommodate higher sea levels. Tidal inundation impacts would be managed by elevating roads and surrounding Harbor areas. Oceanside Harbor Beach would be nourished, while oceanfront/adjacent structures are raised to avoid wave run-up impacts.

8.1.2 The Strand

Along the Strand, near-term coastal hazards would be managed by expanding and upgrading shoreline protection devices, elevating buildings in the wave run-up and flood hazard zones, and expanding beach nourishment. These adaptation strategies are repeated until 2070, when the Strand is deconstructed and utilities are relocated. By this time, many structures would be raised above the coastal floodplain under this adaptation scenario but remain exposed to wave run-up on the ground level during storms. Additional buildings are elevated as needed to avoid flooding impacts in the long-term as beach nourishment is continued.

8.1.3 Wisconsin Avenue to Buena Vista Lagoon

Adaptation south of the Strand from Wisconsin Avenue to the southern city limits near Buena Vista Lagoon includes shoreline protection device expansion/upgrades and beach nourishment through 2100 to manage coastal erosion and wave run-up. However, some buildings would be elevated at the southern end of the reach to avoid wave run-up impacts. Long-term, armor maintenance and beach nourishment would continue and additional buildings would be elevated where needed to avoid coastal flooding impacts. A bulkhead is included along a portion of homes to manage coastal flooding in Buena Vista Lagoon.

8.1.4 Long-term

Beyond the long-term timeline (i.e., after 2070-2100), it is expected that water levels may become too high and erosion may threaten structures on the beach so that they can no longer be maintained. Additional adaptation will be needed

in the future and would likely include managed retreat of structures west of Pacific Street. Pacific Street south of Wisconsin Avenue is expected be lost in the 2100-2140 timeframe, so adaptation would likely be needed for structures along Pacific Street, including changing property access to Tait Street, where possible. In addition, roads, parking areas and structures around the Harbor would need to be raised further to elevate above tidal inundation, and bulkheads would need to be raised to protect against extreme tides.

8.2 Adaptation Scenario Analysis Methodology

To estimate the total cost of each adaptation scenario over the study period for the purpose of the cost benefit analysis, the adaptation scenario was defined through time by assigning schedules for individual adaptation strategies (at what year to build/maintain armor, (re)nourish beach, build floodwall etc.). The schedules were determined based on the projected coastal erosion, storm flooding and tidal inundation hazard extents examined in the VA. The following assumptions are noted for the adaptation scenario development:

- The adaptation scenario schedule and associated cost timing is based on the high-range sea-level rise scenario of 5.7 ft by 2100.
- The adaptation scenario does not address river flooding (i.e. 1% annual chance storm event) in Loma Alta, Buena Vista Lagoon, and San Luis Rey River.
- Breakwater maintenance is not included in the Adaptation Scenario.

Engineering adaptation costs and associated benefits for the adaptation scenario were then compared against the impacts of the baseline (do-nothing) scenario analyzed in the VA. The Economic Cost Benefit Analysis Methodology and Results is provided in Appendix A. The timing and valuation of individual adaptation strategies, a summary of the economic analysis, and an overview of the results are provided below.

8.2.1 Timing of Adaptation Strategies

Individual adaptation strategies (e.g., beach nourishment, coastal armoring, raising structures) were compiled to create a adaptation scenario that addresses the various exposures to public and private property as identified in the VA. The timing is based on the high-range sea-level rise scenario of 5.7 ft by 2100.

For erosion-specific adaptation strategies, a shoreline evolution model was applied to track beach width, shoreline erosion and backshore erosion (where applicable) through time. This approach relied on historic shoreline erosion rates, the high-range sea-level rise amounts considered for this study (NRC 2012) and the historic Oceanside beach nourishment rate of 200,000 cubic yards per year (based on USACE harbor dredging records). This average nourishment volume was distributed along the entire shore of Oceanside for

each year. The model output of beach width also enables the valuation of recreational benefits and discussion of ecology.

For storm flooding- and inundation-specific adaptation strategies, specific sea-level rise triggers were identified by reviewing the coastal hazard maps used for the VA. Storm flooding impacts were used to define the timing of raising/ expanding bulkheads in the Harbor and elevating buildings along the coast. Tidal inundation impacts set the schedule for elevating roads, parking, and buildings around the Harbor, along with some buildings on the Strand. Tidal inundation exposure was addressed in two phases: features exposed to inundation by 2025 were elevated at 2020 to mitigate impacts up to 2070, whereas additional areas exposed by 2070 were elevated at 2060 to mitigate impacts up to 2100.

Shoreline protection devices such as rock revetments and seawalls are subject to degradation over time and require maintenance (USACE 1984). Coastal structures are designed for a particular condition, such as wave height, which may be exceeded due to an occurrence of a more severe storm event. Consequently, it is assumed that the useful life of existing shoreline protection devices in the city are limited and that:

- Existing shoreline protection devices will be reconstructed at 2020 along with the addition of new structures where applicable.
- Structures are maintained every 30 years and will need to be built larger in the future to manage higher sea-levels and associated increased intensity and duration of wave run-up.

Each individual adaptation strategy is maintained through 2100 to manage coastal hazards identified in the VA.

8.2.2 Valuing Infrastructure and Adaptation Strategies

The adaptation scenario discussed above was used to develop conceptual level engineering cost estimates using the unit costs provided in **Table 8-1** below. These costs were compiled from past studies and/or estimated for this project by ESA and vetted with the City. The goal of engineering cost estimates is to achieve an understanding of the order of magnitude of costs; these conceptual estimates are not meant to substitute for a detailed engineering cost estimate. The actual costs may be 50% less to 100% greater than the costs developed for this study (AACE 2016) which is consistent with the industry standard practice for this planning level of analysis.

Table 8-1. Engineering Unit Costs for Adaptation Strategies and Asset Replacement

	Cost	Unit	Description
Adaptation Strategy			
Elevate Buildings	$150	per SF	In flood zone
Elevate Buildings	$250	per SF	in wave zone
Elevate Road	$800	per SF	elevate on bridge/trestles
Rock Revetment	$6,629	per LF	quarry stone
Seawall	$10,795	per LF	reinforced Concrete
Bulkhead/Floodwall	$2,200	per LF	elevate Harbor bulkheads
Beach Nourishment	$22	per CY	offshore sediment dredged to site
Demo Building	$16	per SF	demolish buildings
Demo Revetment	$500	per LF	demo revetment and haul nearby
Demo Road (2 lanes)	$50	per LF	demo road
Demo pavement	$1	per SF	demo paved area
Deliver/Compact fill	$70	per CY	fill for elevating ground
New pavement	$4	per SF	parking area
Infrastructure Type			
Water	$360	per LF	water delivery main
Communications	$100	per LF	Comcast replacement estimate
Wastewater	$190	per LF	collection pipe
Wastewater	$380	per LF	pressure main
Transportation	$400	per LF	typical 2 lane road w curbs
Transportation	$310	per LF	Strand replacement cost

Table 8-2 below summarizes the general methods and sources that were used in the economic analysis. Details on the valuation of economic benefits associated with the adaptation scenario and other methods are described in Appendix A.

Table 8-2. Engineering Unit Costs for Adaptation Strategies and Asset Replacement

Estimate	Valuation	Method	Source
Residential Land	Market	Update Parcel Data	San Diego County/ Zillow
Commercial Land	Market	Update Parcel Data	San Diego County/ Zillow
Publicly Owned Land, Land Trusts	Acquisition Cost	Apply acreage metric	City of Oceanside Insurance Appraisals
Publicly Owned Buildings	Appraisals		City of Oceanside Insurance Appraisals
Demolition Costs	Removal Costs	Apply sq ft. metric	ESA
Beach Attendance	Non-Market Valuation	Day Use Value * Attendance	City of Oceanside
Beach Spending/Taxes	Money/Taxes generated in Oceanside	Per Visitor	SANDAG Beach Survey/CPI
Biking Trail Attendance	None	City Counters	City of Oceanside
Utility Replacement Costs	Replacement/ Reconfiguration Costs	Apply linear ft. metric	ESA
Roads	Replacement/ Reconfiguration Costs	Apply linear ft. metric	ESA

8.3 Adaptation Economic Analysis Results

The economic analysis can be used to help inform adaptation decisions. The economic analysis uses the best available data on property values, coastal recreation, and tax revenues. The limitations of the data and analysis are discussed in more detail in Appendix A. The analysis includes estimates of losses in Transient Occupancy Taxes (TOTs, including the City's recent Oceanside Tourism Marketing District Assessment –OTMD) and sales taxes generated for the City by beach tourism.

The economic analysis compares the costs and benefits of two courses of action: The baseline scenario ("do nothing") measures the benefits of beach recreation over time against the costs of increasing erosion, storm flooding and tidal inundation over time. The adaptation scenario measures the benefits of beach recreation against the cost of engineering strategies designed to preserve the sandy beach as well as protect property from erosion and flooding.

Table 8-3 and **Figure 8-1** below summarize the cost benefit analysis for the baseline and adaptation scenarios. In particular, the final row presents the

comparative benefits of adaptation over those of the baseline. The costly investments to adaptation begin to pay off as the overall benefits of adaptation begin to outweigh those of the baseline scenario. While the adaptation scenario is costly in the short run ($150 million less in benefits than the baseline through 2025), it is preferred to the baseline scenario in the long run when those early investments begin to pay off ($410 million more in benefits than the baseline through 2040, and upward from there). By 2100, the adaptation scenario is valued at $2.18 billion above the baseline.

Table 8-3. Total Costs and Benefits of Baseline and Potential Adaptation Scenarios

Costs/ Benefits	2019 (0 m SLR)	2025 (0.25 m SLR)	2040 (0.5 m SLR)	2070 (1.0 m SLR)	2100 (1.75 m SLR)
Baseline Scenario					
Erosion Losses	$0	-$2,700,000	-$10,000,000	-$37,900,000	-$46,700,000
Flood Damages	-$10,000	-$90,000	-$360,000	-$940,000	-$1,190,000
Recreation Value	$0	$1,011,000,000	$2,461,000,000	$3,711,000,000	$3,859,000,000
PV Total	**-$10,000**	**$1,010,000,000**	**$2,450,000,000**	**$3,670,000,000**	**$3,810,000,000**
Potential Adaptation Scenario					
Armoring	-$77,000,000	-$77,000,000	-$77,000,000	-$123,000,000	-$135,000,000
Flood Protection	-$55,000,000	-$99,000,000	-$109,000,000	-$127,000,000	-$127,000,000
Nourishment	-$4,000,000	-$24,000,000	-$68,000,000	-$115,000,000	-$135,000,000
Retreat	$0	$0	$0	-$2,100,000	-$2,100,000
Recreation Value	$0	$1,060,000,000	$3,110,000,000	$5,390,000,000	$6,390,000,000
PV Total	**-$140,000,000**	**$860,000,000**	**$2,860,000,000**	**$5,020,000,000**	**$5,990,000,000**
Net Benefits (Adaptation over Baseline)					
PV Total	**-$140,000,000**	**-$150,000,000**	**$410,000,000**	**$1,350,000,000**	**$2,180,000,000**

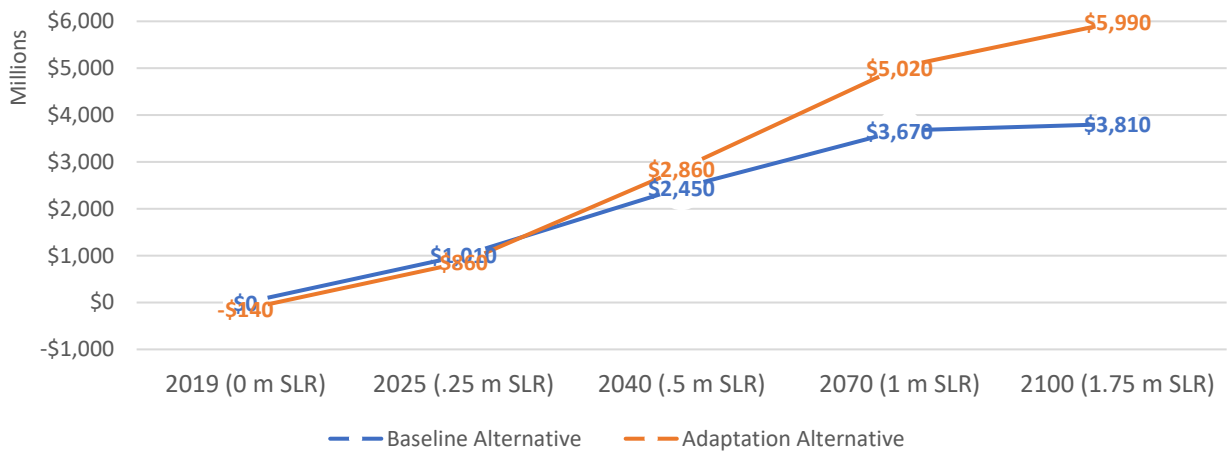


Figure 8-1. Comparison of Baseline and Potential Adaptation Benefits over Time 2019-2100

Section 9

IMPLEMENTATION AND NEXT STEPS

This section describes the tools, programs and policies, and funding sources that can help the City take action and implement the adaptation strategies identified in this Adaptation Plan.

9.1 City Tools to Facilitate Implementation

The City can choose from a variety of existing policy, regulatory, and procedural tools to facilitate the implementation of the adaptation strategies identified in this Adaptation Plan. These include:

1. **General Plan** – Goals, objectives, policies, and implementation measures could be developed and incorporated into the General Plan to ensure consistency with this Adaptation Plan.
2. **Local Coastal Program (LCP) –** the City will be amending the Land Use Plan to incorporate adaptations strategies. The City will also be amending the Implementation Plan in the near future.
3. **Hazard Mitigation Plan –** The County is currently updating the hazard mitigation plan to include an evaluation of the impact climate change will have on the natural hazards that face the County. The City could collaborate with the County to incorporate vulnerabilities and mitigation measures that relate to sea-level rise consistent with this Adaptation Plan.
4. **Capital Improvement Plan/Program** - For adaptation strategies that require capital expenditures, the Capital Improvement Plan/Program is an appropriate place to address priorities, funding, and scheduling of implementing adaptation strategies.
5. **Administrative policies, procedures and initiatives**. The City could amend or create administrative policies, procedures, and initiatives that would direct City staff efforts towards implementation of certain adaptation planning actions, such as:
    a. Establishing a process and identifying a lead department for monitoring the trajectory towards planning-level adaptation triggers (identified in Section 3.2).
    b. Participating in regional coordination efforts.

c. Preparing a short-term action plan that acts as a staff-level plan and details key steps to take over the next two years.

Amendments to these plans and programs can help to establish a policy and regulatory framework for implementation. They could also improve the City's ability to seek funding from state and federal agencies.

9.2 Implementation Programs and Policies

The following are programs, policies, and standards that would serve to implement the adaptation strategies identified in this Adaptation Plan.

Regional Coordination

There are several key agencies that the City should coordinate with as it moves forward with adaptation planning. These include:

- SANDAG – The City should coordinate with SANDAG to advocate for and participate in regional nourishment programs that would benefit Oceanside's beaches. Coordination with adjacent down-coast Cities like Carlsbad could lead to cost-sharing for nourishment in Oceanside that would also be advantageous to down-coast Cities.
- California Department of Transportation – The City could work with California Department of Transportation to better understand the risk of storm-related flooding on the I-5 bridge over the San Luis Rey River and to discuss feasible adaptation strategies.
- USACE – The City should continue to coordinate with USACE to facilitate the ongoing dredging of the federal navigational channel in the Harbor. The City could also explore and purse partnerships with USACE in reconnaissance and feasibility studies for new projects related to navigation, coastal flood hazard reduction, and/or habitat restoration that would serve as adaptation strategies. USACE partners with local jurisdictions in joint local-federally sponsored projects and can provide Federal funding for implementation for projects that are shown to have a Federal interest based on feasibility studies and cost/benefit ratios following USACE guidelines. The City should also encourage the preparation of the USACE-led San Diego County Shoreline Feasibility Study which is currently on-hold pending federal funding.
- San Diego Regional Climate Collaborative – The City should continue to participate in the San Diego Regional Climate Collaborative group to share best practices and information with other local and regional agencies on climate change planning, including addressing coastal hazards.
- Marine Corps Base Camp Pendleton – Camp Pendleton is currently in the process of assessing the vulnerability of their facilities to sea-level rise. The City could collaborate with Camp Pendleton to identify mutually beneficial adaptation strategies that support Camp Pendleton, and the Harbor and Oceanside beaches.

Education and Outreach Programs

Engaging and communicating with the community on an ongoing basis is essential to ensuring that adaptation strategies can be successfully and efficiently implemented. Public engagement offers the opportunity to educate and build commitment and consensus among decision-makers and community members. The following are outreach materials and programs the City could implement:

1. Develop a "Property Owner's Guide to Preparing for Sea-Level Rise" to help property owners navigate the regulatory system to elevate or otherwise retrofit structures to accommodate sea-level rise. Topics could cover:
    a. City permitting process
    b. Coastal Development Permit requirements
    c. Agency compliance (FEMA, CCC, etc.)
    d. Key sea-level rise hazard standards
2. Develop and distribute technical information and guidance on home retrofitting options which could include elevation, wet/dry flood proofing, flood gates, drainage improvements, etc.
3. Establish a citizen's science monitoring program for community members to gather data on sea-level rise impacts which could include measuring beach widths, documenting king tides and flooding, documenting flooding and property damage, etc.
4. Continue to pursue funding and partnerships to formalize a sea-level rise public education program for high school students.

Community Plans

The City could facilitate the development of Community Plans for Adapting to Coastal Hazards (Community PATCHs) in conjunction with community members and asset managers for smaller scale planning centered around vulnerable assets of community-wide importance. The development of such plans would require the following steps:

- Identify subarea boundaries for prioritization, possibly based on timing, area of impact, costs, equity, environment, economy, etc.;
- Develop planning timeframes around the point at which flooding creates recurring significant problems; and
- Evaluate adaptation alternatives with cost estimates in more detail, which may include armoring, elevation, realignment, etc.

Overlay Zones

An overlay zone is a land use planning tool which establishes additional regulations and incentives over an existing base zone. Special provisions, identified as part of the overlay zone, would supersede those provisions of the

base zone, where applicable, to promote orderly planned development and to provide protection of the public's health, safety, and general welfare. An overlay zone could provide a singular reference for coastal hazard and sea-level rise land use regulations. For example, studies, disclosures, or development standards could be required for properties located within the overlay zone. The process for designating overlay zones could include the development of coastal flood and erosion maps that include areas that will be subject to tidal inundation, wave action, storm flooding, and erosion due to sea-level rise. The maps would need to be regularly updated to reflect best available science on sea-level rise projections and associated hazard areas.

Downzoning

This strategy refers to changing the existing zoning of land to a zoning district that is less intense than its previous zone. More often, this measure is taken to limit sprawl in unincorporated areas or to limit over-intensification of cities; however, it could be used to limit redevelopment and development in hazardous areas in order to lessen the amount of damage a flood event could incur.

Setbacks for Development

A commonly used tool for guiding development farther away from coastal hazards are setbacks. Setbacks ensure structures are set back far enough inland from the beach or bluff edge such that they will not be endangered by erosion (including sea-level rise induced erosion) over the life of the structure, without the use of a shoreline protective device. When used to address future risk, setbacks are normally defined by a measurable distance from an identifiable location such as a bluff edge, line of vegetation, dune crest, or roadway. Setbacks standards can be prescriptive by defining a specific distance that development must be placed, or they can be defined based on site-specific analyses that determine the appropriate size of the setback based on established criteria.

The City's LCP establishes a "string line" setback for beachfront homes between Wisconsin Avenue and the southern city limits. Over 30 years ago, lines were drawn generally along the seaward edge of existing development on the beach. The LCP requires that redevelopment or new structures be placed behind the string line in order to prevent any further encroachment seaward of existing development footprints. The intent of the standard is to protect views of the beach and public access along the beach.

Flood Hazard Standards

Applicable building codes could be revised to enable structures to withstand higher water levels within areas susceptible to sea-level rise hazards. Standards could require:

- Additional setbacks

- Increased base floor elevations
- Limited first floor habitable space
- Floodable or waterproofed standards

As described in Section 5.3.4 and 6.3.5, raising structures would help to limit damage from coastal and river/creek flooding. Standards for new development could require structures to account for additional freeboard elevation to accommodate anticipated levels of sea-level rise for the expected life of the structure. This requirement would be in addition to the existing requirement that structures be raised above the base flood elevation as established on FEMA National Flood Insurance Program Maps. The sea-level rise amount would be calibrated to the amount of sea-level rise that could occur during the anticipated life of the structure according to the best available science (e.g., 75 years for residential). Abandoning the lowest floor or elevating the lowest habitable floor are also effective in reducing damages to the buildings.

Floodable standards involve adapting a home to allow floodwaters to enter and exit without causing major damage to the home or its contents. Floodable or wet flood proofing measures include, flood openings, elevating building utilities, flood proofing building utilities, or the use of flood damage-resistant materials. Waterproofed, or dry flood proofing, measures involve sealing the structure to prevent floodwaters from entering. Barrier measures can be built around a structure to contain or control flood waters, including floodwalls or levees with or without gates (FEMA 2019).

Fee Simple Acquisition and Purchase with Lease Back Option Programs

A fee simple acquisition program is the purchase of vacant or developed land in order to prevent or remove property from the danger of coastal hazards, such as erosion. As an erosion avoidance measure, for example, this technique would transfer the erosion risks from the current property owner to the group or entity willing to acquire the property. Typically, a fee simple acquisition is done to remove the property from being developed and prevent the construction of buildings or other capital improvements that would eventually be in danger from erosion. It could be used for purchasing developed properties at-risk from sea-level rise related hazards which would require the demolition and removal of existing structures and improvements, and restoration of the site to support natural physical processes. Restoring habitat and providing improved public access could be additional actions that are taken. Fee simple acquisition of waterfront properties can, in some cases, be prohibitively expensive.

However, one hybrid approach could involve the creation of a public acquisition program in which an entity purchases the property and leases or rents back the land to the previous landowner until the property becomes uninhabitable. This hybrid may enable public investment to recover some of the initial purchase cost. The program could target areas that could be eroded

or inundated by tides within a few decades. The private landowner who are willing to sell early would receive market-rate returns on their real estate investment. Ideally, a 30-year mortgage would be paid in full prior to the property experiencing severe sea-level rise and/or storm events.

Conservation Easements

A conservation easement is a legally enforceable agreement attached to the property deed between a landowner and a government agency or a non-profit organization that restricts development "for perpetuity" but allows the landowner to retain ownership of the land. The allowable activities and uses within the conservation easement could be restricted so as to allow flooding and erosion processes to occur.

The cost of conservation easements depends on the willingness of the seller, costs associated with maintenance and monitoring of easements, as well as the implementing mechanism. In general, someone has to file, hold, and enforce a conservation easement on the sending parcel to ensure that future land use planning bodies cannot decide to allow development in the sending area. Either local government or a third party (e.g., an NGO) could hold the easement.

Rolling Easements

Another strategy often recommended to facilitate nature-based sea-level rise adaptation are rolling easements. Rolling easements are open space or conservation easements that move or ambulate with some identified reference feature, such as the mean high tide line for coastal properties. As the coast retreats, the easement line migrates along with it, inland on a parcel. Then any development outside of the line is removed and becomes part of that easement. This approach ensures maintenance of beach width and protection of the natural shoreline by requiring humans to yield the right-of-way to naturally migrating shores. Implementation of this strategy can be through a permit condition that restricts the use of shoreline protective structures, limits new development, and encourages the removal of structures that are seaward (or become seaward over time) of a designated boundary. Another approach would be to tie the rolling easement to public trust lands. The easement can be written to expressly state that land, which becomes subject to the public trust as a result of sea-level rise, reverts back to the state. In California, public trust lands include land at the mean high tide line and seaward. Rolling easements may be implemented by statute or, more typically, by specifying that a conservation easement "roll" or move landward as the shore erodes. Like all easements, rolling easements will require some regular inspection and potential enforcement.

Transfer of Development Rights (TDR)

TDR programs allow the transfer of the development rights from one parcel to another parcel. These programs are tools used by land use planners to direct development away from certain sensitive areas (source sites) and into areas that can better accommodate it (receiver sites). TDRs, could be applied

where undeveloped sensitive or hazardous parcels exist and desirable areas to transfer potential development to are available. TDR programs are widespread throughout the country and vary based on local land use planning priorities and needs. While the design specifics are left to the discretion of a local government, in general a TDR program identifies source sites (from which development rights are taken away) and receiver sites (to which a development right is added). The owner of a source site can sell a TDR to the owner of a receiver site. The seller typically retains ownership of the "sending" property, but relinquishes the right to develop it, while the buyer is able to intensify development on the receiver site more than would otherwise be permitted under existing zoning. Source or sending sites may be sensitive land areas such as areas prone to coastal hazards. Owners of source sites receive monetary compensation from the sale of the TDR and in the form of potentially lower property taxes, while owners of receiver sites have assurance of future development rights on their site. TDR programs may provide a higher level of certainty over traditional zoning efforts because of the specificity of the amount and location of future development.

Real Estate Disclosure

Upon any real estate transaction, this policy strategy would require the disclosure of potential hazards to buyers of property in a coastal hazard zone. This disclosure would inform buyers of potential hazards associated with the established coastal hazard zone, including erosion, coastal flooding, and tidal inundation, as a result of sea-level rise. The inclusion of this type of disclosure provides limited liability protections for the local jurisdiction, and educates landowners and potential buyers on the risk of owning property in a hazardous area.

9.3 Funding Sources and Mechanisms

Adaptation planning is a challenging undertaking and will require adequate funding to design, permit, implement, and maintain adaptation strategies (see Section 8). Although there are state and federal grant programs that are available to support adaptation planning, to sustainably implement adaptation strategies, a community should develop a layered funding strategy that starts with local investment, and leverages those monies with grants, loans, and private sector investments. This demonstrates the community's commitment to a more self-reliant financial future. This section identifies both grant funding opportunities as well as local funding strategies.

Grant Funding Sources

FEMA Hazard Mitigation Assistance

FEMA administers three programs that provide assistance to local governments (as well as state and tribal governments) for reducing the risk of loss of life and property from future disasters (FEMA 2019).

1. The Hazard Mitigation Grant Program assists in implementing long-term hazard mitigation planning and projects following a Presidential major disaster declaration. Typical mitigation projects funded through the Hazard Mitigation Grant Program include:
   - Acquisition and structure demolition/relocation
   - Preparation of hazard mitigation plans
   - Mitigating flood conditions, such as through floodplain and stream restoration or green infrastructure methods
   - Raising homes or structural retrofitting existing buildings
2. The Pre-Disaster Mitigation Program provides funds for hazard mitigation planning and projects on an annual basis, including the development and implementation of hazard mitigation plans. The goal is to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding in future disasters. This program awards planning and project grants and provides opportunities for raising public awareness about reducing future losses before disaster strikes. Grants are funded annually by Congressional appropriations and are awarded on a nationally competitive basis.
3. The Flood Mitigation Assistance Program provides funds for planning and projects to reduce or eliminate risk of flood damage to buildings that are insured under the National Flood Insurance Program on an annual basis. Generally, local communities will sponsor applications on behalf of homeowners and then submit the applications to the State. Funding is appropriated by Congress annually.

California Department of Fish and Wildlife – 2019 Proposition 1 & Proposition 68 Grant Opportunities

Proposition 1 (Water Quality, Supply, and Infrastructure Improvement Act of 2014) and Proposition 68 (California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018) are new funding opportunities available through California Department of Fish and Wildlife to support multi-benefit, ecosystem restoration and protection projects. Proposition 1 funds ecosystems and watershed protection and restoration, and water supply infrastructure projects. Funds are distributed via grant programs by multiple state and regional agencies. Proposition 68 funds environmental protection and restoration projects, water infrastructure projects, and flood protection projects. Projects eligible for funding under these grants include: planning activities that lead to specific on-the-ground implementation projects, funds for implementation activities (e.g., construction and monitoring) of restoration and enhancement projects, and funds for acquisition or purchases of interests in land or water.

California Department of Transportation Adaptation Planning Grant Program

The Road Repair and Accountability Act of 2017 established a transportation funding bill that provides a reliable source of funds to maintain and integrate the State's multimodal transportation system (California Department of Transportation, Division of Transportation Planning 2018). A portion of the funds was allocated to an adaptation planning grant program that is intended to advance adaptation planning on California's transportation infrastructure, including roads, railways, bikeways, trails, bridges, ports, and airports. The overarching goal of this grant program is to support planning actions at local and regional levels that advance climate change adaptation efforts on the transportation system, especially efforts that serve the communities most vulnerable to climate change impacts. Example adaptation planning grant project types include:

- Climate vulnerability assessments
- Extreme weather event evacuation planning
- Resilience planning
- Transportation infrastructure adaptation plans
- Natural and green infrastructure planning
- Integration of transportation adaptation planning considerations into existing plans, such as a climate mitigation or adaptation plan, LCP, Local Hazard Mitigation Plan, General Plan (including meeting Senate Bill 379 requirements), or other related planning efforts
- Evaluation of or planning for other adaptation strategies
- Developing educational resources, trainings and workshops for local jurisdictions and transportation service providers on any of the above listed adaptation planning activities.

Potential Funding Mechanisms

Assessment and Abatement Districts

The purpose of an assessment or abatement district is to establish a mechanism by which a city or county can finance the prevention, mitigation, abatement or control of some type of pest, nuisance or hazard. For the purposes of hazards related to beach and bluff front property, Coastal Hazard Assessment Districts (CHADs) and Geologic Hazard and Abatement Districts (GHADs) can be established to implement adaptation strategies described above. CHADs provide a funding reserve for future maintenance, expansion, and rehabilitation of flood and/or erosion control structures. Often financed through the collection of supplemental tax assessments, CHAD revenues are relatively safe with the option to borrow from lenders or issue bonds with attractive credit terms. The establishment of a CHAD or GHAD would allow

for the better assessment of hazards, as well as increase funding for maintenance, repairs, or other similar improvements. This often results in a greater funding reserve and improved maintenance or repair services.

Infrastructure Financing Districts

Enhanced infrastructure financing districts allow for incremental property tax revenues to be devoted to a specific purpose. In 2014, the passage of Assembly Bill; 313 and Senate Bill 628 both 1) further defined enhanced infrastructure financing districts to include: brownfield restoration and other environmental mitigation; transit priority projects; and projects to implement a sustainable communities strategy; and 2) streamlined the requirements for the establishment of these districts. Once the infrastructure financing district is established and priority projects have been identified as part of the business plan, funds can be drawn from changes in local tax revenues occurring as part of a redevelopment or rezone or apply for grant funds.

Establishment of a Shoreline Account

A "Shoreline Account" could be established to serve as the primary account where funds generated for future adaptation programs would be kept in reserve. Funds, subject to the restrictions of any terms of the funding sources, may be used to pay for adaptation-related projects identified in this Adaptation Plan, including the cost to repair and maintain, and to pay for conducting surveys and monitoring programs.

Impact Mitigation Fees or In-Lieu Fees

Impact mitigation fees or in-lieu fees can generate funds for implementing adaptation strategies. Fees could be established to generate revenues for covering the cost to plan for and implement adaptation strategies. The CCC has an in-lieu fee mitigation program in San Diego County to mitigate impacts on shoreline sand supply associated with shoreline armoring. The Report on In-Lieu Fee Beach Sand Mitigation Program: San Diego County (1997) establishes a framework for assessing the adverse and cumulative impacts of shoreline protective devices on shoreline sand supply. It includes a methodology for quantifying the impacts of shoreline protective devices and to calculate a fee. The in-lieu fee mitigation program is specific to permits in San Diego County. The San Diego Association of Governments (SANDAG) collects the fees and administers the fund. The City could incorporate into their LCP a beach replenishment program which is financed, in part, by fees from property protection which encroaches on publicly-owned beach or otherwise adversely affects public beaches. Funds from these fees could be used to implement projects that provide sand to the city's beaches and public recreation/access projects that direct recreation and/or access benefit to the general public.

Green Bonds

Bonds allow municipalities and other entities to borrow money from investors, which is then repaid to the investor over an established period at a certain rate. Often, interest earned on government issued bonds is tax exempt, and are common mechanism for financing public infrastructure and government programs. Green bonds are a new market that has emerged to specifically fund green adaptation infrastructure.

9.4 Next Steps

The immediate next steps for the City to begin implementation of this Adaptation Plan are:

1. Evaluate and prioritize adaptation strategies – decide which of the recommended adaptation strategies are most relevant, most achievable, or of highest priority for implementation.
2. Phase and implement – identify a responsible or lead department, develop action plans with funding sources that articulate the steps necessary to implement the strategies, including updates to the LCP, Capital Improvements Program, and other City tools, and develop a monitoring program to track progress.

Section 10

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Section 11

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Appendix A

Economic Analysis Methodology and Results

Dr. Philip G. King

June 3, 2019

Memo

To: City of Oceanside

From: Dr. Philip King

Re: Economic Analysis of Sea Level Rise Hazards and Potential Adaptation Scenario for the City of Oceanside

Overview of Economic Analysis

Sea-Level Rise (SLR) and associated coastal storms and erosion will place much public and private property in the City of Oceanside at-risk to coastal hazards. The economic analysis prepared for this study is designed to help guide the City and other stakeholders by estimating the value of public and private property at-risk due to coastal hazards, chronic erosion, coastal storm flooding, and chronic tidal inundation, in particular.

The economic analysis can be used to help inform adaptation decisions. The economic analysis provided below uses the best available data on property values, coastal recreation, and tax revenues. The limitations of the data and analysis are discussed in more detail below. The analysis below also includes estimates of losses in Transient Occupancy Taxes (TOTs, including the City's recent Oceanside Tourism Marketing District Assessment –OTMD) and sales taxes generated for the City of Oceanside by beach tourism.

Summary of Results:

The economic analysis compares the costs and benefits of two competing courses of action: The Baseline Scenario ("Do Nothing") measures the benefits of beach recreation over time against the costs of increasing erosion, storm flooding and tidal inundation over time. The suggested Potential Adaptation Scenario measures the benefits of beach recreation against the cost of engineering strategies designed to preserve the sandy beach as well as protect property from erosion and flooding. Table 1 below indicates that, while the Potential Adaptation Scenario is costly in the short run ($150 million less than the baseline through 2025), it is preferred to the Baseline Scenario in the long run when those early investments begin to pay off ($410 million more than the baseline through 2040, and upward from there).

Table 1. Total Costs and Benefits of Baseline and Potential Adaptation Scenarios through 2100

	2019 (0 m SLR)	2025 (.25 m SLR)	2040 (.5 m SLR)	2070 (1.0 m SLR)	2100 (1.75 m SLR)
Baseline Scenario					
Erosion Losses	$0	-$2,700,000	-$10,000,000	-$37,900,000	-$46,700,000
Flood Damages	-$10,000	-$90,000	-$360,000	-$940,000	-$1,190,000
Recreation Value	$0	$1,011,000,000	$2,461,000,000	$3,711,000,000	$3,859,000,000
PV Total	**-$10,000**	**$1,010,000,000**	**$2,450,000,000**	**$3,670,000,000**	**$3,810,000,000**
Potential Adaptation Scenario					
Armoring	-$77,000,000	-$77,000,000	-$77,000,000	-$123,000,000	-$135,000,000
Flood Protection	-$55,000,000	-$99,000,000	-$109,000,000	-$127,000,000	-$127,000,000
Nourishment	-$4,000,000	-$24,000,000	-$68,000,000	-$115,000,000	-$135,000,000
Retreat	$0	$0	$0	-$2,100,000	-$2,100,000
Recreation Value	$0	$1,060,000,000	$3,110,000,000	$5,390,000,000	$6,390,000,000
PV Total	**-$140,000,000**	**$860,000,000**	**$2,860,000,000**	**$5,020,000,000**	**$5,990,000,000**
Net Benefits (Adaptation over Baseline)					
PV Total	**-$140,000,000**	**-$150,000,000**	**$410,000,000**	**$1,350,000,000**	**$2,180,000,000**

Methods

Geospatial Data

Much of the economic analysis provided for this study is based on geospatial data. All of the land, structures, and infrastructure analyzed in this memo have specific geospatial references, which can be overlaid with the hazard analysis (i.e., flooding and erosion).

This economic analysis employed San Diego County Assessor's parcel data, the vulnerability analysis prepared by ESA, and insurance appraisals of City, and other public property for certain land and structures, provided by the City of Oceanside. The County parcel data includes the assessed value of all land and structures that are subject to property tax (i.e., most property other than government property as well as some tax-exempt organizations, i.e. churches). For a variety of reasons, however, the assessed value is often significantly lower than the actual market value of any given property. The primary reason is that California's Proposition 13 limits increases in property tax assessments to 2% per year. This implies that properties purchased before periods of high housing price inflation are often significantly undervalued. To adjust for this inherent bias in the assessment data, we used the best available housing price data to construct a housing priced index (HPI) for the City of Oceanside, which converts the original sales price into current market prices. Since Oceanside's housing market is unique, this study employed a local index based on data from Zillow.

In California, parcels owned by government entities (Federal, State, local including school district property) and tax-exempt organizations (e.g., churches) are not subject to property taxes and, as such, are not assessed. The City of Oceanside provided this study with estimates of the insurance appraisals for the replacement costs of numerous structures that were incorporated into the analysis. Furthermore, this analysis used recent transactions of coastal property by governmental and non-governmental agencies to value land parcels owned by government agencies.

One limitation of using current market prices for land is that these prices depend critically on zoning. Land zoned for residential use will have a different market price than land zoned for commercial or other such land uses. On the one hand, future changes in land zoning as a result of SLR and climate change could change these property values. On the other, the threat of coastal erosion and flooding might also lower the market value of at-risk property in the future while also increasing the value of property that will not be at-risk. Such possibilities, however, are beyond the scope of this analysis.

Roads and Other Infrastructure

The cost of removal and replacement for roads, water pipes, and other infrastructure was estimated by the engineering consultants, ESA. In some cases, infrastructure subject to frequent flooding required flood-proofing. These costs were also estimated by ESA and incorporated into the cost-benefit analysis.

Valuing Recreational Resources

<u>Beach Recreation</u>

In California all beaches below the mean high tide are considered public property; by law, beaches cannot be bought or sold in California, so a market price cannot be established. In addition, since everyone in California has access to beaches, there is no price for admission, though many beaches (including in Oceanside) do charge for parking in official beach parking lots.

Even though beaches other recreational amenities are free, they still have value to the public. Economists measure the value of these non-market resources by estimating what consumers would be willing to pay (WTP) for the services. These methods are generally referred to as **non-market valuation** and are discussed in more detail in Appendix A.

For beach recreation, this study will apply a day use value of $40: a day at the beach is worth $40. This valuation is consistent with a recent case before the Coastal Commission in Solana Beach. The $40 estimate is based on numerous studies of the non-market value of beaches in California. To estimate the total value of beach recreation, one multiplies the day use value ($40) by the number of people attending the beach. For example, if 100,000 people attend a beach in 2018, the value of the beach is equal to

$$Day\ Use\ Value * Annual\ Attendance = Recreation\ Value$$

or

$$\$40 * 100{,}000 = \$4\ million.$$

Erosion and Flooding

Estimating precisely when a coastal hazard impacts the value of a parcel is challenging. Coastal erosion may lower the property value as people's expectations about future erosion change. However, this analysis assumed that the land value of a parcel loses value in proportion to the loss in property:

$$Percent\ of\ land\ value\ lost\ to\ erosion = Percent\ of\ land\ lost\ to\ erosion.$$

Thus, if a parcel loses 20% of its land value, it loses 20% of its land (as opposed to structural improvement) economic value. Once erosion hits a structure, however, this study assumed that the

entire market value of the structure is lost since, it is assumed, the structure must be abandoned. In practice, however, a structure will likely lose its value before erosion actually hits the structure.

Flood damages to structures were estimated by applying the U.S. Army Corps of Engineers depth damage curves (USACE, 2003). These curves estimate coastal storm damages as a percent of the total value of the structure. The Corps' method also permits us to estimate the average damage to the contents of the structure (e.g., furniture, inventory, etc.). These curves translate flood depth into a flood damages and losses as a percent of the total, structural improvement value. The percentage loss also varies with the number of stories, type of construction, and other factors. Given that flood damages also depend upon the length of the flooding, the force of the waves, and other unknown variables, the flood estimates provided in this study have a greater margin of error than many other estimates, but still provide a useful base for comparing alternatives. Estimates of flooding are limited to coastal storm wave run-up. While riverine flooding from the San Luis Rey river is also a significant hazard, there are no currently available metrics by which we might estimate these damages and losses.

Storm Losses

The estimates of storm losses contained in this study are for a one-percent probability storm event, often referred to as a 100-year storm. The expected losses to coastal flooding are evaluated, applying flood depths damage curves provided by the USACE and FEMA. The probability of the storm striking within the given time horizon is1% per year). Thus, if a parcel that has structural improvements valued at $500,000 is vulnerable to coastal flooding between 2056 and 2085, at a flood depth corresponding to a 50% loss, the expected losses will be:

$$Improv.Value * Depth\ Curve * Annual\ Prob. * Present\ Value\ Discount = Expected\ Losses$$

Or:

$$\$500{,}000 * 50\% * 1\% * \underset{n=2056}{\overset{2085}{\text{SUM}}} (1.03)^{(2019-n\ )} \approx \$16{,}900.$$

As such, the expected value of such future losses are significantly less than the damages to very same property were the storm to strike today:

$$\$500{,}000 * 50\% * 100\% * (1.03)^0 = \$250{,}000.$$

This significant difference in storm flooding loss estimates is entirely due to the differences in storm probabilities and future discounts, both of which must be kept in mind when interpreting the results below. (See discussion below for more regarding the future and time discounts.) With warming ocean water temperatures and climate change in general, however, the frequency of these 100-year storms may increase.

Taxes

Climate change and SLR will have implications for the City of Oceanside's tax base. One of the primary drivers of changes in taxes will be changes in beach visitation, prompted by beach erosion. If the City of Oceanside's beaches erode, fewer visitors will spend money on hotels, food, and other items in the City. The primary taxes generated by beach visitation are transient occupancy taxes (TOTs, including the City's recent Oceanside Tourism Marketing District Assessment –OTMD), though some City sales tax

dollars are also generated from restaurant, gas and other sales in the City. This study provides estimates of TOTs and sales taxes generated and lost by beach recreation.

Summary of Methods and Sources

Table 2 below briefly summarizes the general methods and sources to be used in this study.

Table 2. Data Sources for Economic Study

Estimate	Valuation	Method	Source
Residential Land	Market	Update Parcel Data	San Diego County/Zillow
Commercial Land	Market	Update Parcel Data	San Diego County/Zillow
Publicly Owned Land, Land Trusts	Acquisition Cost	Apply acreage metric	City of Oceanside Insurance Appraisals
Publicly Owned Buildings	Appraisals		City of Oceanside Insurance Appraisals
Demolition Costs	Removal Costs	Apply sq ft. metric	ESA
Beach Attendance	Non-Market Valuation	Day Use Value * Attendance	City of Oceanside
Beach Spending/Taxes	Money/Taxes generated in Oceanside	Per Visitor	SANDAG Beach Survey/CPI
Biking Trail Attendance	None	City Counters	City of Oceanside
Utility Replacement Costs	Replacement/ Reconfiguration Costs	Apply linear ft. metric	ESA
Roads	Replacement/ Reconfiguration Costs	Apply linear ft. metric	ESA

The Future

The economic analysis in this study projects the impacts of sea-level out to 2100. However, our current understanding of the impacts of climate change is limited and evolving. Furthermore, our understanding of future economic conditions and market prices/replacement costs is similarly limited, especially for longer time horizons.

The economic analysis for this study estimates all prices and replacement cost in (real) 2019 dollars. Effectively this assumption implies that the relative prices/costs of various decisions/options will remain the same over time—that is, the inflation rate for all goods and services will be the same. However, it is likely that some costs/prices will rise faster than others while new technologies or techniques may lower the relative prices of other goods and services.

As is standard in any economic benefit/cost analysis, future costs and benefits must be discounted—future benefits/costs are worth less than the same benefit/cost today. The choice of discount rate is critical in any benefit/cost analysis. Currently, there is no consensus among economists as to what the proper discount rate should be.[1] When considering capital investments (e.g., financing a seawall) one should consider the cost of capital—what it actually costs to borrow the necessary funds to finance a project. Currently, short and long term interest rates are relatively low, and the cost of financing a

[1] For example, see Arrow et al., 2014 and Zuang et al. (2007).

project through Federal, State or local bonds is in the 3% to 5% range. However, even a relatively low discount rate can imply that benefits and costs for future generations are valued far less than current benefits (as shown above). Many economists have argued that the social discount rate should be lower than the market cost of capital.[2] It must be kept in mind, however, that both costs and benefits in both the Baseline and Potential Adaptation Scenarios are uniformly discounted. As such, while a change in the discount rate might shift the magnitude of future costs and benefits, it cannot change which scenario (baseline or adaptation) is preferable to the other.

Table 3 below shows the discounted value of a $100 benefit in future time horizons. When projecting out to 2100, even a relatively low discount rate, such as 3%, implies that a $100 benefit in 2100 is worth less than one-tenth of what it would be worth today-- $8.86 (see table 3 below). Effectively, a higher discount rate values benefits to future generations much lower than benefits to today's generation. **This study employs a 3% discount rate in all benefits and costs projected out to the future**.

Table 3. Value of $100 over Time at Various Discount Rates

Discount Rate	0%	1%	2%	3%	4%	5%
2030	$100.00	$89.63	$80.43	$72.24	$64.96	$58.47
2060	$100.00	$66.50	$44.40	$29.76	$20.03	$13.53
2100	$100.00	$44.67	$20.11	$9.12	$4.17	$1.92

Estimates of Property Losses

Chronic Erosion

Table 4 and Figure 1 below presents estimates of expected property losses due to erosion. As one can see, the economic value of property losses is relatively low even at 2040. However, losses accelerate by 2070 and 2100. The biggest exposure for property losses by far are residential structures, many along the south Oceanside coast, where beach widths are narrower. More specifically, the Jr. Seau Community Center and the 800-900 blocks of S. Pacific St., among other residential areas, become vulnerable to erosion by 2070. By 2100, the Rancho Santa Margarita y Las Flores area becomes especially vulnerable. Due to their temporal non-proximity, these significant vulnerabilities are more clearly reflected in the "No PV" totals provided in the bottom row of the table.

Table 4. City of Oceanside: Estimated Property Value Losses to Erosion ($2019)

Land Use	2019 (0 m SLR)	2025 (.25 m SLR)	2040 (.5 m SLR)	2070 (1.0 m SLR)	2100 (1.75 m SLR)
Residential	$0	$2,700,000	$10,000,000	$37,400,000	$46,000,000
Recreation	$0	$0	$0	$500,000	$500,000
Public/Govt.	$0	$0	$0	$0	$200,000
PV Totals	**$0**	**$2,700,000**	**$10,000,000**	**$37,900,000**	**$46,700,000**
Totals (No PV)	$0	$3,600,000	$17,100,000	$143,400,000	$241,100,000

[2] *Ibid*.

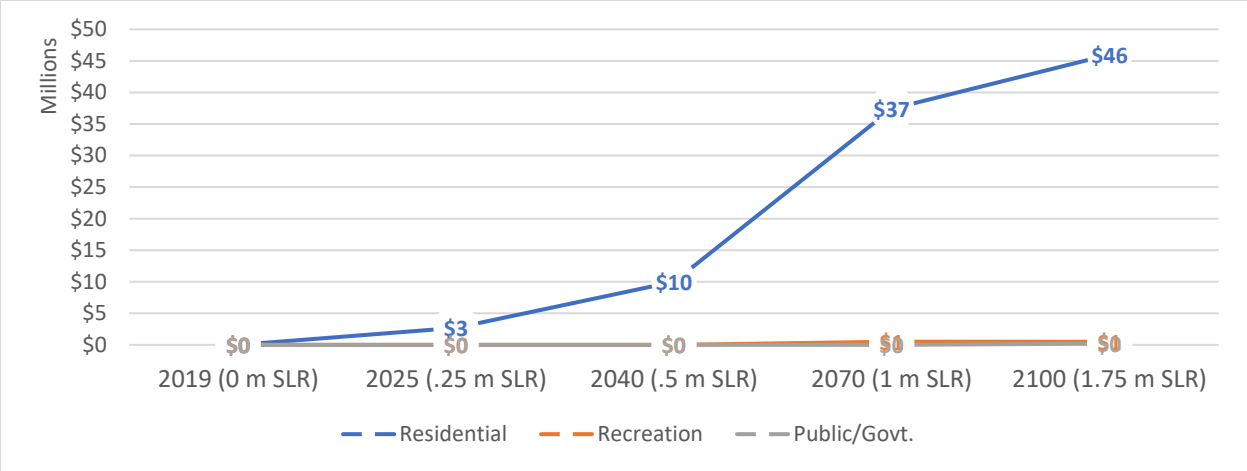

Figure 1. City of Oceanside: Estimated Property Value Losses to Erosion ($2019)

Figure 2 below presents losses to residential property in the City of Oceanside. Fortunately, the primary vulnerability is to land (orange and yellow lines) rather than structures. It is not until 2070 that residential structures begin to be impacted by erosion. Furthermore, while the multi-family structures at Rancho Santa Margarita y Las Flores account for most of the grey line - and become vulnerable by 2100 - the losses to single-family structures are not so concentrated, but are instead spread out over a number of residential properties.

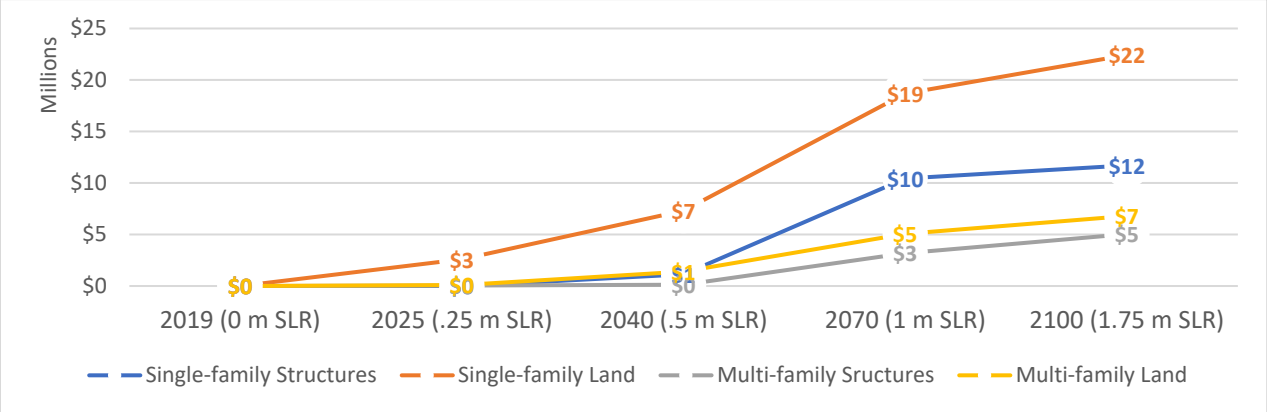

Figure 2. City of Oceanside: Estimated Residential Property Value Losses to Erosion ($2019)

Damages due to Storm Flooding

Table 5 and Figure 3 below presents estimates of losses due to storm damages and flooding from a 1% (aka 100-year storm) event. As with chronic erosion, most of these damages will occur on residential property. As one reads these tables, one should keep in mind that these estimates only include estimates for 100-year storms, not other types of storms. As with chronic erosion, the biggest increase in damages occurs during the 2040-2070 time periods.

Table 5. City of Oceanside: Estimated Property Value Losses to Coastal Flooding ($2019)

Land Use	2019 (0 m SLR)	2025 (.25 m SLR)	2040 (.5 m SLR)	2070 (1.0 m SLR)	2100 (1.75 m SLR)
Residential	$0	$60,000	$220,000	$610,000	$680,000
Recreation	$0	$0	$47,000	$163,000	$227,000
Public/Govt.	$5,000	$34,000	$92,000	$168,000	$280,000
PV Totals	**$5,000**	**$94,000**	**$359,000**	**$941,000**	**$1,187,000**
Totals (No PV)	$10,000	$100,000	$450,000	$1,620,000	$2,540,000

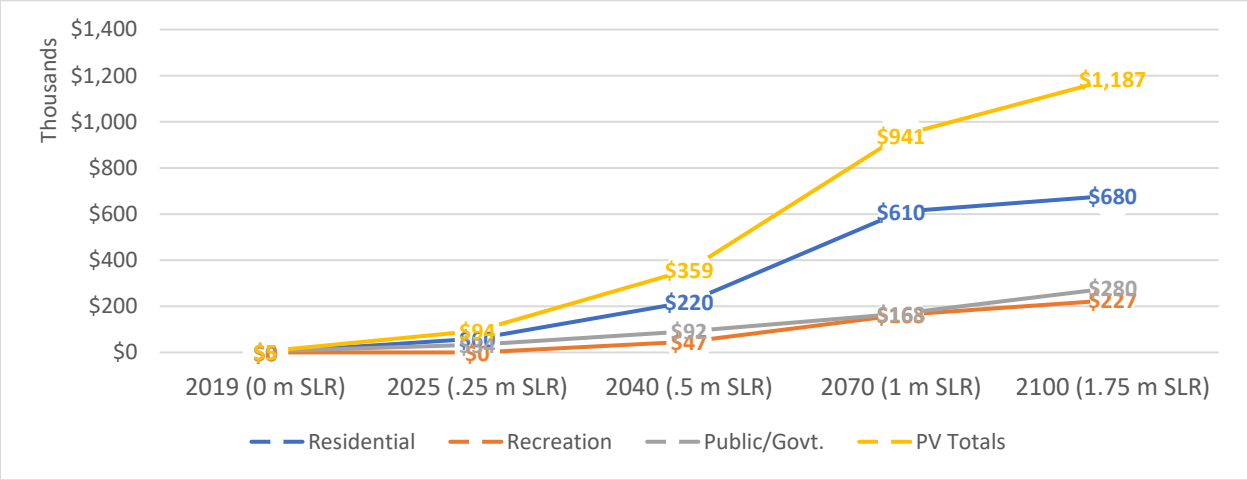

Figure 3. City of Oceanside: Expected Property Value Losses to Coastal Flooding ($2019)

As was the case with erosion (above) the most significant parcels vulnerable to coastal flooding will be the Rancho Margarita y Flores structures as well as the Jr. Seau Community Center, both of which become vulnerable by 2070. Figure 4 below further breaks down the residential estimates according to type. A collection of single-family residence represent the most significant asset vulnerabilities, with Rancho Margarita y Flores accounting for most of the multi-family structures.

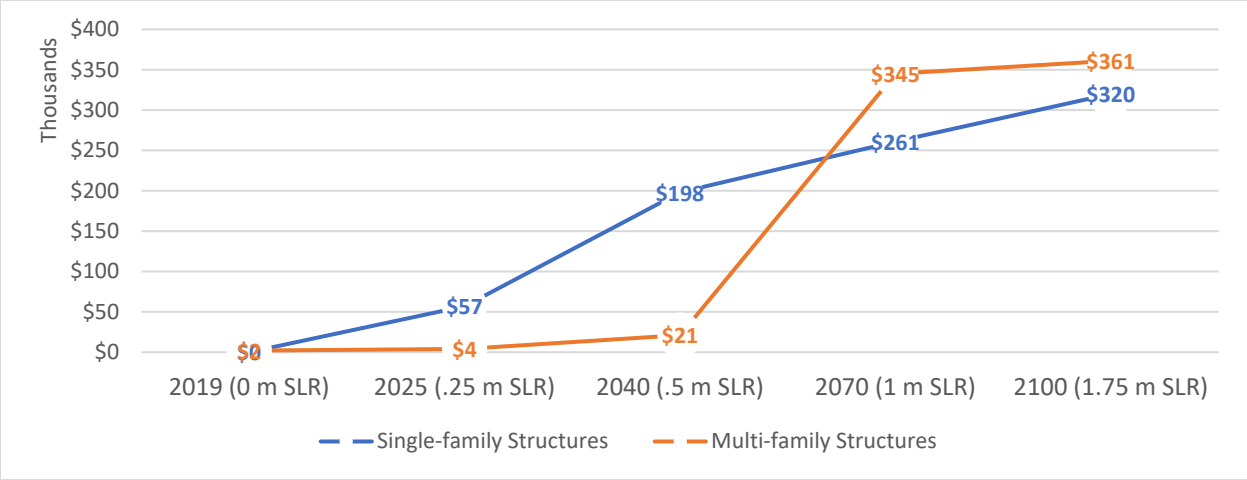

Figure 4. City of Oceanside: Expected Residential Property Value Losses to Coastal Flooding ($2019)

Exposure to Chronic (Tidal) Inundation

Table 6 below presents this study's estimates of property value subject to chronic (sometimes referred to as tidal) inundation. **Unlike the estimates above, these estimates are for the value of property subject to (or exposed to) tidal flooding, not the expected damages or losses**. Once again, residential property is most at risk, as the Rancho Margarita y Flores residences are currently exposed to such inundation. Determining the actual value of these losses is difficult, however. That said, we do predict chronic inundation to gradually diminish property values and increase maintenance/flood prevention costs.

Table 6. City of Oceanside: Estimated Property Subject to Chronic (Tidal) Inundation ($2019)

Land Use	2019 (0 m SLR)	2025 (.25 m SLR)	2040 (.5 m SLR)	2070 (1.0 m SLR)	2100 (1.75 m SLR)
Commercial	$0	$100,000	$100,000	$100,000	$200,000
Residential	$26,300,000	$31,900,000	$32,100,000	$32,300,000	$33,700,000
Recreation	$0	$0	$0	$0	$200,000
Public/Govt.	$3,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000
PV Totals	**$29,300,000**	**$36,000,000**	**$36,200,000**	**$36,400,000**	**$38,100,000**
Totals (No PV)	$29,200,000	$37,200,000	$37,500,000	$38,700,000	$57,200,000

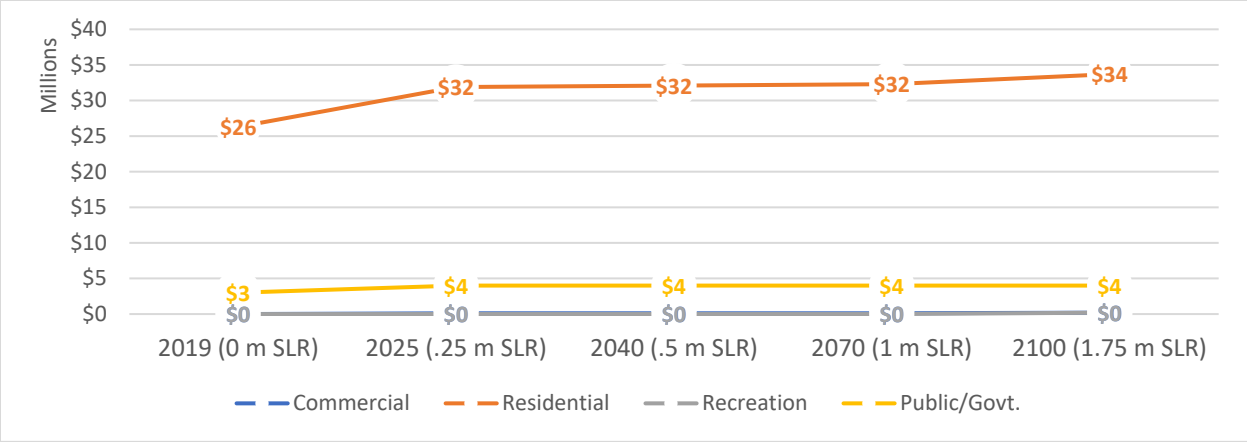

Figure 5. City of Oceanside: Estimated Property Subject to Chronic (Tidal) Inundation ($2019)

Figure 6 below breaks down the residential exposure according to type. As noted above, the Rancho Margarita y Flores area accounts for nearly half of the residential exposure to tidal inundation, with the other half being distributed among several single-family residences. The parking area at 1301 N. Pacific St. accounts for the majority of the public/government assets that are exposed.

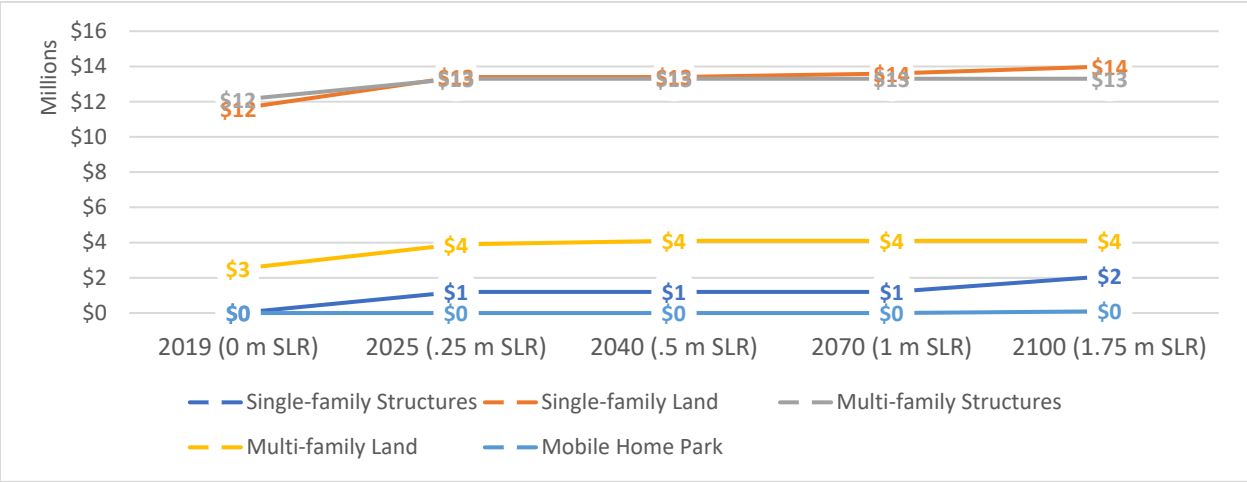

Figure 6. City of Oceanside: Estimated Residential Property Subject to Chronic (Tidal) Inundation ($2019)

Economic Value of Beach Recreation

As mentioned in the methodology section above, economists generally categorize beach recreation under "non-market valuation." Admission to public beaches is free (except perhaps for parking) even though beach recreation clearly has value to beach-goers. This non-market value is equivalent to what the average person would be willing to pay (WTP) for a day at the beach. Although WTP varies by individual, numerous studies in southern California have estimated WTP and arrived at a range of values. This study uses an average of these estimates, which is approximately $40/day.

Beach attendance estimates were provided by the City. This study used an average of the last five years—which is 4.7 million visits per year. This study divided Oceanside long beach front into three distinct reaches: Harbor Beach (north of the jetty and adjacent to the Harbor), The Strand (from Lifeguard Tower 1 to Tower 7 at Wisconsin Ave.), and south Oceanside (from Wisconsin to the border with Carlsbad). The tables below combine the analysis of all three reaches. This study also assumes that, unless impeded, attendance will grow by 0.5% per year, in line with population projections for San Diego County.

To estimate future attendance, this analysis assumed that visitors require 100 square feet per person per day of "towel space." The study further assumed a turnover of 3.2 people per day. Further the demand for beach capacity is not uniform throughout the by year, but peaks during the summer months, in particular weekends and holidays mid-summer. To account for the variation in demand, this analysis used daily data from southern California beaches to estimate demand during peak and non-peak days.

Non-market Value under Current Conditions

Table 7 below presents estimates of attendance under current conditions. Note that although the demand for future beach use is expected to increase with population, beach erosion will severely limit beach attendance over time, from 4.7 million people today to 4.3 million in 2025, 3.4 million in 2040, and then quickly falling thereafter. By 2100 there will essentially be no beach under current conditions. As attendance falls, the non-market value also falls significantly. The last two columns present the non-market value in today's (2019) dollars and discounted (present value) at 3% per year.

Table 7. Estimated Attendance and Non-Market Value for Selected Years

Year	Est. Attendance Baseline	Est. Non Market Value Baseline	PV Non Market Value Baseline
2019	4,700,000	$187,100,000	$187,100,000
2025	4,300,000	$170,300,000	$146,900,000
2040	3,400,000	$135,400,000	$75,000,000
2070	1,900,000	$77,000,000	$17,600,000
2100	0	$0	$0

Table 8 presents the cumulative non-market values for various time horizons from 2019 to 2100. Over this entire time horizon, this non-market value is quite high: $7.3 billion (undiscounted). However, as one can see, the value diminishes significantly over time due to beach erosion.

Table 8. Estimated Cumulative Non-Market Value for 2019-2100

Years	Est. Non Market Value Baseline	PV Non Market Value Baseline
2019-2025	$1,090,000,000	$1,010,000,000
2026-2040	$2,100,000,000	$1,450,000,000
2041-2070	$3,320,000,000	$1,250,000,000
2071-2100	$800,000,000	$150,000,000
Total	**$7,310,000,000**	**$3,860,000,000**

Bike Trail Usage

We similarly used data provided by the City of Oceanside to, in Table 9 and Figure 7 below, estimate the annual usage of two local bike trails: The San Luis Rey River Trail and the Coastal Rail Trail. While small compared to beach visitation, bike trail usage is not insignificant, especially along the San Luis Rey River which is most exposed to ocean water levels and beach erosion, along with riverine flooding. The Coastal Rail Trail, by contrast, is relatively well protected from such hazards.

Also worthy of note is the steady decline in these annual figures. To be sure, attendance estimates are notoriously inexact, and 4 years of data is not enough to establish a reliable trend with much confidence. That said, the data we do have show an average decline in bike trail usage of approximate 5%.

Table 9. Estimated Annual Usage of Bike Trails

	2014	2015	2016	2017
San Luis Rey Trail	303,000	274,000	284,000	254,000
Coastal Rail Trail	n/a	n/a	56,000	52,000
Total	**303,000**	**274,000**	**340,000**	**306,000**

*usage data for 2014 and 2015 was unavailable for the Coastal Rail Trail.

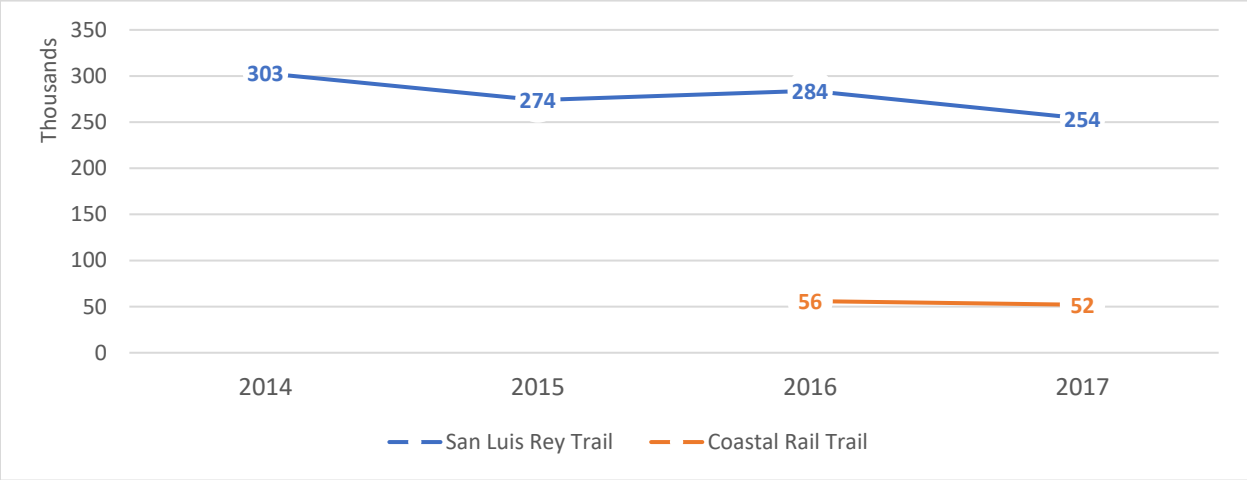

Figure 7. Slight Decline in Bike Trail Usage

Beach Spending and Taxes generated under Current Conditions

Tables 10 and 11 below present estimates of spending in the City by beach visitors with the former presenting the figures for individual years while the latter sums up such figures over various time horizons. Currently, visitors spend $113 million per year on beach related activities, generating $4.7 million in transient occupancy taxes and $260,000 in sales tax revenues for the City of Oceanside. Over time, this will diminish as beaches erode.

Table 10. Estimated Spending and Taxes Generated in Oceanside for Selected Years

Year	Baseline: Total Beach Spending	Baseline: Sales Taxes Generated	Baseline: TOT/TMDA
2019	$113,400,000	$300,000	$4,700,000
2025	$103,200,000	$200,000	$4,300,000
2040	$82,100,000	$200,000	$3,400,000
2070	$46,600,000	$100,000	$1,900,000
2100	$0	$0	$0

Table 11. Accumulated Estimated Spending and Taxes Generated in Oceanside for 2019-2100

Years	Baseline: Total Beach Spending	Baseline: Sales Taxes Generated	Baseline: TOT/TMDA
2019-2025	$658,000,000	$1,510,000	$27,100,000
2026-2040	$1,274,000,000	$2,920,000	$52,500,000
2041-2070	$2,015,000,000	$4,610,000	$83,100,000
2071-2100	$482,000,000	$1,100,000	$19,900,000
Totals	**$4,429,000,000**	**$10,140,000**	**$182,700,000**

Non-market Value with Adaptation

This section estimates the attendance and non-market value with and without adaptation, which includes substantial increases in beach width/area through nourishment. As shown below (Table 12), with adaptation, beach attendance increases over time with population growth, whereas it is constrained within the baseline due to beach erosion. Table 13 provides estimates of the summed benefits within various timeframes.

Table 12. Estimated Attendance and Non-Market Value for Selected Years

Year	Est. Attendance Baseline	Est. Non Market Value Baseline	PV Non Market Value Baseline	Est. Attendance Adaptation	Est. Non Market Value Adaptation	PV Non Market Value Adaptation
2019	4,700,000	$187,100,000	$187,100,000	4,700,000	$188,100,000	$188,100,000
2025	4,300,000	$170,300,000	$146,900,000	4,800,000	$192,600,000	$166,200,000
2040	3,400,000	$135,400,000	$75,000,000	5,100,000	$203,700,000	$112,800,000
2070	1,900,000	$77,000,000	$17,600,000	5,500,000	$218,600,000	$49,900,000
2100	0	$0	$0	5,700,000	$227,800,000	$21,400,000

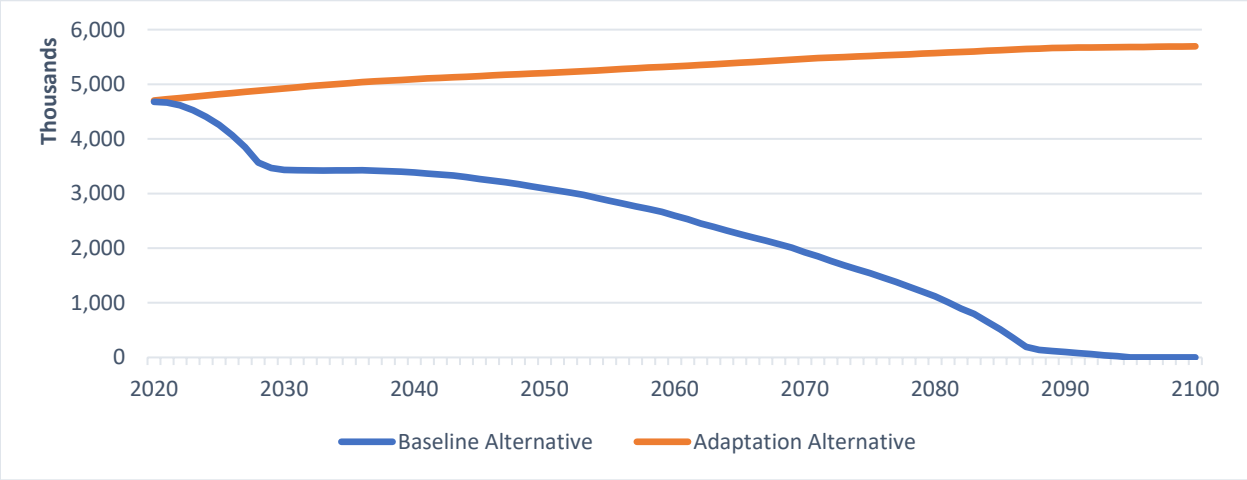

Figure 8. Estimated Annual Attendance for Baseline and Potential Adaptation Scenario at Oceanside Beaches 2019-2100

Table 13. Estimated Cumulative Non-Market Value for selected Years: 2019-2100

Years	Est. Non Market Value Baseline	PV Non Market Value Baseline	Est. Non Market Value Adaptation	PV Non Market Value Adaptation	PDV Net Benefits of Adaptation
2019-2025	$1,090,000,000	$1,010,000,000	$1,140,000,000	$1,060,000,000	$50,000,000
2026-2040	$2,100,000,000	$1,450,000,000	$2,990,000,000	$2,050,000,000	$600,000,000
2041-2070	$3,320,000,000	$1,250,000,000	$6,330,000,000	$2,280,000,000	$1,030,000,000
2071-2100	$800,000,000	$150,000,000	$6,730,000,000	$1,000,000,000	$850,000,000
Total	**$7,310,000,000**	**$3,860,000,000**	**$17,190,000,000**	**$6,390,000,000**	**$2,530,000,000**

Beach Spending and with Adaptation

Tables 14 and 15 are similar to those above, only instead of non-market value, they estimate the spending and taxes generated due to beach visitation. As before, these are significantly higher over time with adaptation.

Table 14. Estimated Spending and Taxes Generated in Oceanside for Selected Years

Years	Baseline: Total Beach Spending	Baseline: Sales Taxes Generated	Baseline: TOT/TMDA	Adaptation: Total Beach Spending	Adaptation: Sales Taxes Generated	Adaptation: TOT/TMDA
2019	$113,400,000	$260,000	$4,680,000	$114,000,000	$261,000	$4,680,000
2025	$103,200,000	$236,000	$4,260,000	$100,700,000	$267,000	$4,790,000
2040	$82,100,000	$188,000	$3,380,000	$68,400,000	$283,000	$5,060,000
2070	$46,600,000	$107,000	$1,920,000	$30,200,000	$303,000	$5,430,000
2100	$0	$0	$0	$13,000,000	$300,000	$5,700,000

Table 15. Estimated Spending and Taxes Generated in Oceanside for 2019-2100

Years	Baseline: Total Beach Spending	Baseline: Sales Taxes Generated	Baseline: TOT/TMDA	Adaptation: Total Beach Spending	Adaptation: Sales Taxes Generated	Adaptation: TOT/TMDA
2019-2025	$660,000,000	$1,510,000	$27,100,000	$640,000,000	$1,590,000	$28,400,000
2026-2040	$1,270,000,000	$2,920,000	$52,500,000	$1,240,000,000	$4,140,000	$74,200,000
2041-2070	$2,020,000,000	$4,610,000	$83,100,000	$1,380,000,000	$8,790,000	$157,400,000
2071-2100	$480,000,000	$1,100,000	$19,900,000	$610,000,000	$9,340,000	$167,300,000
Totals	**$4,430,000,000**	**$10,140,000**	**$182,700,000**	**$3,870,000,000**	**$23,860,000**	**$427,300,000**

Engineering Costs of Adaptation

As indicated earlier, the Potential Adaptation Scenario involves significant construction and engineering costs, even though this early investment does pay off in the longer-run. Table 16 and Figure 9 below break these engineering costs down into four types: Armoring and revetments, Flood and inundation protection, Nourishment of sandy beaches, and a managed Retreat of building and structured from encroaching sea water. While both armoring and flood protection are most costly up front, the costs of nourishment gradually increase over time until each of the three will cost approximately $130 million by 2100. The costs of managed retreat, however, are comparatively small and late coming.

Table 16. Accumulative Engineering Costs for Potential Adaptation Scenario 2019-2100

	2019 (0 m SLR)	2025 (.25 m SLR)	2040 (.5 m SLR)	2070 (1.0 m SLR)	2100 (1.75 m SLR)
Armoring	$76,800,000	$76,800,000	$76,800,000	$123,300,000	$134,800,000
Flood Protect.	$55,300,000	$98,500,000	$109,400,000	$126,600,000	$127,100,000
Nourishment	$4,300,000	$24,100,000	$68,500,000	$115,200,000	$134,500,000
Retreat	$0	$0	$0	$2,100,000	$2,100,000
Total Costs	**$136,400,000**	**$199,400,000**	**$254,600,000**	**$367,300,000**	**$398,500,000**

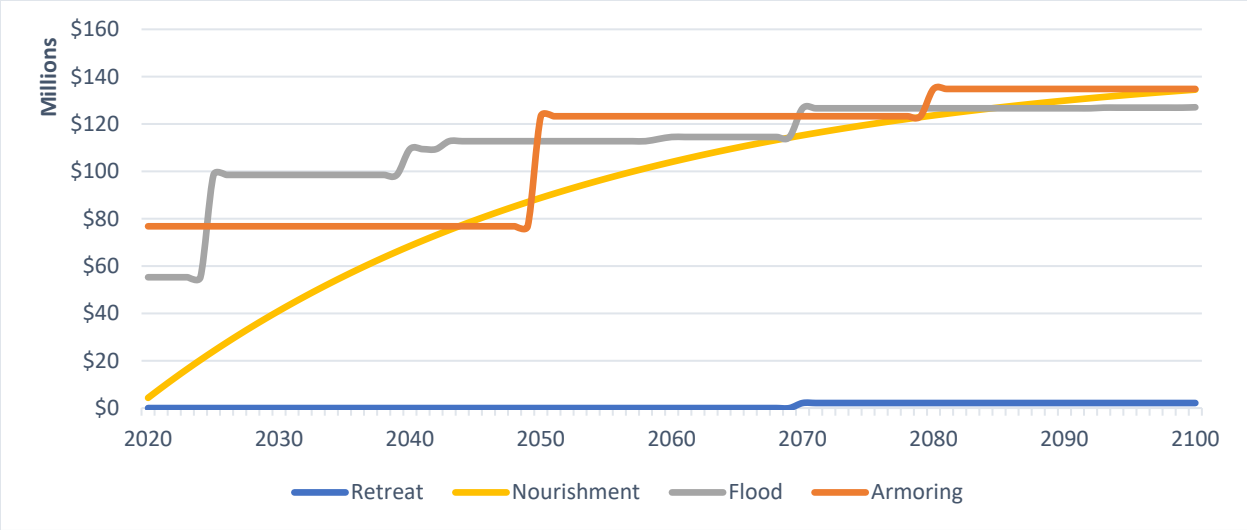

Figure 9. Accumulative Engineering Costs for Potential Adaptation Scenario 2019-2100

Comparative Benefits of Adaptation

Table 17 and Figure 10 below summarize our cost benefit analysis for the Baseline and Potential Adaptation Scenario. In particular, the final row presents the comparative benefits of Adaptation over those of the Baseline. The row indicates that, due to the significant up front costs of adaptation, the Baseline is (unsurprisingly) preferred over adaptation by $140 million and $150 million within the two shortest time horizons. These costly investments to adaptation, however, do begin to pay off as the overall benefits of adaptation soon begin to outweigh those of the Baseline. By 2100, the Potential Adaptation Scenario is valued at $2.18 billion above the Baseline.

Table 17. Accumulative Costs and Benefits of Baseline vs. Adaptation Strategies

	2019 (0 m SLR)	2025 (.25 m SLR)	2040 (.5 m SLR)	2070 (1.0 m SLR)	2100 (1.75 m SLR)
Baseline Scenario					
Erosion Losses	$0	-$2,700,000	-$10,000,000	-$37,900,000	-$46,700,000
Flood Damages	-$10,000	-$90,000	-$360,000	-$940,000	-$1,190,000
Recreation Value	$0	$1,011,000,000	$2,461,000,000	$3,711,000,000	$3,859,000,000
PV Total	**-$10,000**	**$1,010,000,000**	**$2,450,000,000**	**$3,670,000,000**	**$3,810,000,000**
Potential Adaptation Scenario					
Armoring	-$77,000,000	-$77,000,000	-$77,000,000	-$123,000,000	-$135,000,000
Flood Protection	-$55,000,000	-$99,000,000	-$109,000,000	-$127,000,000	-$127,000,000
Nourishment	-$4,000,000	-$24,000,000	-$68,000,000	-$115,000,000	-$135,000,000
Retreat	$0	$0	$0	-$2,100,000	-$2,100,000
Recreation Value	$0	$1,060,000,000	$3,110,000,000	$5,390,000,000	$6,390,000,000
PV Total	**-$140,000,000**	**$860,000,000**	**$2,860,000,000**	**$5,020,000,000**	**$5,990,000,000**
Net Benefits (Adaptation less Baseline)					
PV Total	**-$140,000,000**	**-$150,000,000**	**$410,000,000**	**$1,350,000,000**	**$2,180,000,000**

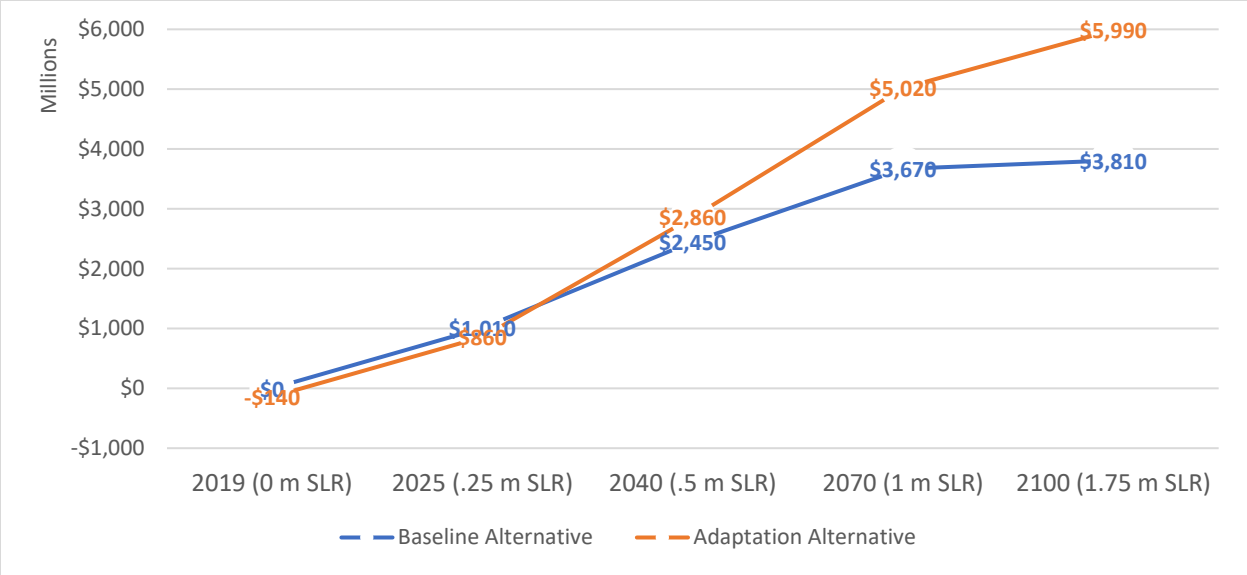

Figure 10. Comparison of Baseline and Adaptation Benefits over Time 2019-2100

Sensitivity of Results to Annual Attendance

Because recreation values play such a disproportionate role within this analysis, we must keep in mind the degree to which these results depend upon our assumed day use value ($40 per day) and annual attendance estimates (4.7 million visits per year).

King and McGregor (2012) show that beach attendance estimates often have an upward bias. we thus provide a sensitivity analysis for these results to annual attendance estimates. These results show that, so long as the annual beach attendance at oceanside is greater than 1 million visits per year, the accumulative benefits of the Potential Adaptation Scenario will eventually outweigh those of the baseline. Indeed, the higher the annual attendance, the sooner will the benefits of adaptation outweigh its upfront costs. For example, if annual attendance is only 1 million, then the Potential Adaptation Scenario will not be preferred to that of the baseline until the 2080's (when the orange line crosses the horizontal axis). If the attendance number is 2 million, then adaptation beats out the baseline approximately by 2045.

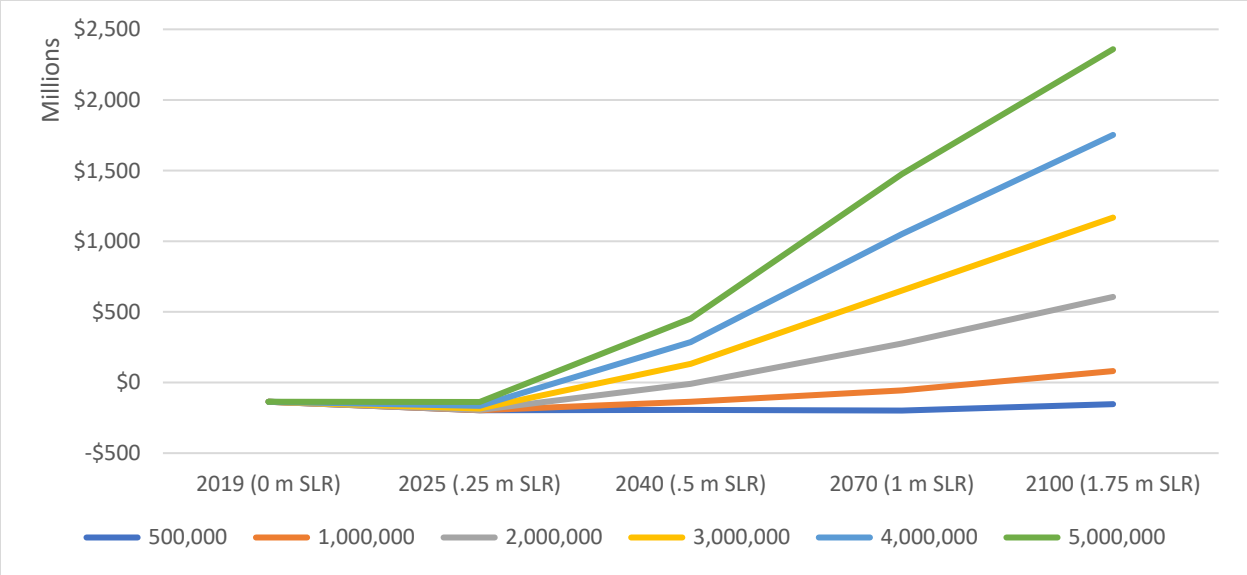

Figure 11. Sensitivity of Comparative Benefits from Adaptation (less Baseline) to Annual Attendance Estimates

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Appendix A: Non-Market Valuation

The economic analysis employed for the City of Oceanside's adaptation planning includes estimates of the non-market value of beach recreation. Beaches in California a public property up to the mean high tide line, therefore beaches are "free." However, visitors are willing to pay significant amounts (e.g., in terms of travel cost) to go to the beach. Therefore, the fact that beaches are free does not mean that they do not have value. Economists classify recreation at beaches as well as other ecosystem services that beaches provide as non-market. The non-market value cannot be determined from a market price, which is for services and goods that can be bought and sold.

To determine the non-market values, economists suggest using the concept of willingness to pay, which is defined as the value of an individually consumed non-market good as the amount that an individual consumer would be willing to pay to consume the good or use the service (e.g., see Raheem et al., 2009, Barbier et al. 2011). The analysis below relies on numerous studies of non-market value discussed below. The analysis of future sea levels and shoreline retreat provided in the previous chapter indicated that all three reaches (West Newport, Balboa Peninsula, and Corona del Mar beaches) are subject to erosion from a 100-year storm.

Beaches provide services with different non-market economic values. These services include recreational value, storm-buffering capacity, and provision of biological and ecological diversity (CDBW, 2011, Barbier et al., 2011). In California, beaches below the high water line are in public trust, and there is no market value for them. One of the recommended methods to determine the non-market values of a beach is to divide its value into use and non-use values. The use values include but not limited to direct use benefits such as recreation (boating, birding, fishing, etc.), and indirect use benefits including flood control, shoreline protection, and groundwater discharge. The non-use values include biodiversity, cultural, and heritage existence benefits.

The recreational value of beaches in California has been studied extensively. This non-market value is typically measured in terms of "willingness to pay" (WTP) for a trip to the beach. Economists can measure WTP by estimating the travel cost to and from the site (revealed preference) or by asking visitors how much they would be willing to pay (stated choice). Most of the studies cited below are travel cost models (e.g., see Parsons, 2003. This WTP is typically expressed as a "day-use value"

Table A-1 Estimates of Day-Use Value for California Beaches

Region	Counties	Usage Level*	Studies	CS Values ($2018)
Southern	San Diego Orange Los Angeles Ventura Santa Barbara	High	12	$15.66[1]
				$22.63[2]
				$25.39[3]
				$29.06[2]
				$31.81[2]
				$35.24[1]
				$36.42[4]
				$39.88[2]
				$47.31[5]
				$99.67[1]
				$109.98[6]
				$116.67[6]
		Low	0	
Central	San Luis Obispo Monterey Santa Cruz San Mateo San Francisco	High	1	$50.29[6]
		Low	0	
Northern	Marin Sonoma Mendocino Humbolt Del Norte	High	0	
		Low	0	
CA Average		N/A		$50.13
Midpoint Kildow & Pendleton (2006)		N/A		$41.87[7]

[1] Leeworthy & Wiley (1993)
[2] King (2001) – midpoint between two methods
[3] Chapman and Hanemann (2001) – corrected for inflation using CPI
[4] Lew and Larson (2005)
[5] Lew (2002)
[6] Leeworthy (1995)
[7] Midpoint of Kildow & Pendleton (2006) adjusted for inflation ($2015)

As indicated in table A-1 above, estimates of day-use value vary by study and by beach with valuations range from $15 to $116 per consumer surplus per day ($2018 dollars). As indicated in Table 5 above, the average is $50.13 (2018 dollars). However, following Kildow and Pendleton (2006) this study used the median value of $41.87 per visitor per day (again in 2015 dollars) rounded to $40 per person per day. This method is also consistent with a recent coastal commission decision in Solana Beach (2017).