COUNTY OF VENTURA
RESOURCE MANAGEMENT AGENCY | PLANNING DIVISION

VC RESILIENT COASTAL ADAPTATION PROJECT

SEA LEVEL RISE ADAPTATION STRATEGIES REPORT

August 30, 2019

County of Ventura
Resource Management Agency - Planning Division
800 South Victoria Ave
Ventura, CA 93009

CALIFORNIA COASTAL COMMISSION

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ACKNOWLEDGEMENTS

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The sea level rise models used to compile this report were developed by the following organizations:

2012 Coastal Resilience Ventura Model:

- The Nature Conservancy, California Chapter
- County of Ventura
- Environmental Science Associates (ESA)

2017 Coastal Storm Modeling System (CoSMoS v3.0):

- United States Geological Survey
- California Coastal Conservancy

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CONTENTS

ACRONYMS/ABBREVIATIONS

BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
Coastal Resilience Model	Coastal Resilience Ventura Project (The Nature Conservancy, County of Ventura, and Environmental Science Associates, 2012)
CoSMoS	Coastal Storm Modeling System of the United States Geologic Survey
County	County of Ventura
FEMA	Federal Emergency Management Agency
LCP	Local Coastal Program
OPC	Ocean Protection Council
Report	2019 VC Resilient Coastal Adaptation Project Sea Level Rise Adaptation Strategies Report
SLR	Sea Level Rise
USFWS	United States Fish and Wildlife Service

DEFINITIONS

The following terms are defined for the purpose of use in this Report:

1% Annual Chance Storm: often called a 100-year storm event, it is an exceptionally large storm with a 1% chance of occurring in any given year. It is the basis for the FEMA regulatory flood maps. In rivers it is based on streamflow, and on the open coast it is based on wave run up.

Adaptation: anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the vulnerabilities.

Adaptation Pathway: an adaptation pathway is a planning approach addressing the uncertainty and challenges of climate change decision-making. It enables consideration of multiple possible futures and allows analysis/exploration of the robustness and flexibility of various options across those multiple futures.

Adaptive Management: a process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effect and changes in the system brought on by resulting feedback effects and other variables.

Adaptive Capacity: the ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, and to cope with the consequences.

Base Flood Elevation: reflects the height (in feet) above sea level that flood water is predicted to rise during a 1% annual chance storm. Base Flood Elevations are shown on FEMA Flood Insurance Rate maps. The relationship between the BFE and a structure's actual elevation above sea level determines flood insurance premiums.

Coastal Armor: structures developed for shoreline protection constructed from durable materials such as rock and reinforced concrete. In Ventura County, most shoreline protective devices consist of seawalls and rock revetments.

Coastal Erosion: loss of land in the dunes or cliffs along the coast caused by wave attack.

Coastal Flooding: pooling of seawater on land as a result of any wave uprush with momentum that causes damage. A 1% annual chance storm would cause coastal flooding, but common storm events may also cause coastal flooding.

Coastal Zone: a regulatory zone established by State Legislature and shown on maps prepared by the California Coastal Commission for which the California Coastal Act establishes policies and regulations.

Climate Change: a shift in climate and weather patterns over time, due to natural causes or as a result of human activity.

Cumulative Effects: the interconnected land use, ecological, social, and economic systems, and how these systems change during the past, present, and future, particularly with sea level rise.

Ecosystem Services: the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems that contribute to the natural, social, and economic well-being of society.

Littoral Cell: an area of coastline that contains the complete cycle of sedimentation, including sources, transport pathways, and sinks. The presence of sand on any beach depends on the transport of sand within the littoral cell.

Long-term Adaptive Capacity: the viability of an adaptation measure with 5 feet or more of sea level rise. The extent to which harmful secondary and cumulative effects are minimized is also considered.

Maladaptation: inadvertently increases the vulnerability to sea level rise hazards and can be a result of badly planned adaptation actions or decisions that place greater emphasis on short-term outcomes than longer-term threats.

Mean High Tide Line: the average of the higher high water height of each tidal day, as observed over a 19-year period by the National Ocean Service.

Risk: commonly considered to be the combination of the likelihood of an event and its consequences – i.e., risk equals the probability of climate hazard occurring multiplied by the consequences a given system may experience.

Secondary Effects: the way different adaptation measures that are used to alleviate a vulnerability in one sector then interact with the adaptation measures applied to other sectors. Socially equitable adaptation measures do not benefit one population to the detriment of another or reinforce existing environmental and societal inequities.

Sector: a category of natural or built resources, such as building structures, wastewater infrastructure, beach access, and sensitive biological resources.

Tidal Inundation: flooding caused during predictable high tides that occurs with some regularity.

Vulnerability Assessment: the process of identifying, quantifying, and prioritizing the potential exposure of resources or infrastructure in an area or a system. A Sea Level Rise Vulnerability Assessment was completed for the unincorporated areas of Ventura County in December 2018.

REPORT, MAP, AND DATA DISCLAIMER

This information is intended to be used for planning purposes only. There are inherent uncertainties associated with modeling and projecting future hazards and their potential impacts. All model results are subject to uncertainty due to limitations in the data used, incomplete knowledge of all factors that contribute to coastal hazards and sea level rise, and simplifications of those factors. This Adaptation Strategies Report is advisory and not a regulatory or legal standard of review for actions that the County of Ventura or the California Coastal Commission may take.

This Report is part of an ongoing process to understand and prepare for coastal hazards. We do not accept responsibility for any errors, omissions, or for any positional inaccuracies. Users of the data included with this report are strongly cautioned to verify all information. Additional monitoring and site-specific specific evaluations may be needed to verify the information presented herein.

1. INTRODUCTION

Throughout California's coastal communities there is growing concern and a desire to plan for the anticipated harmful effects of sea level rise. Climate experts estimate that by 2100, the sea level will rise by 5 feet or more, although the specific timing and magnitude of impacts is difficult to predict. In the near term, the rising sea level alone will not be the primary cause of damage to local resources and infrastructure. Rather, coastal erosion and temporary coastal flooding during large storm wave events such as those that occur during El Niño and King tides are predicted to increase in frequency and intensity as the sea level rises.

This Adaptation Strategies Report (Report) expands upon the 2018 Ventura County Vulnerability Assessment which identified unincorporated areas that could be exposed to hazards such as coastal erosion, coastal wave flooding, and tidal inundation in the future as the sea level rises. Preparation of this Report followed the Vulnerability Assessment as the next step in initial adaptation planning. The Vulnerability Assessment was a starting point for a common understanding of the risks, but it did not provide solutions. There are few easy solutions and all of them require additional public input and additional funding. As an informational document, this Report expands upon the Vulnerability Assessment to provide a foundation for developing future sea level rise policies to be integrated into the County's Local Coastal Program (LCP). Adaptation planning will remain an iterative process to protect the County's coast as conditions change, advances in sea level rise science are published, and new adaptation strategies are developed and tested.

This Report assumes the reader is generally familiar with the unincorporated Ventura County coastline and has reviewed the Vulnerability Assessment. Building off of the Vulnerability Assessment, this Report provides a comprehensive overview of the various adaptation strategies that could be employed to protect the County's vulnerable assets for future generations. The State of California is still in its infancy as far as establishing a robust toolbox for responding to sea level rise at the local level. As such, some of these strategies are tested, some are experimental in nature; others have been successfully employed in marshes or bays, but never in the context of the high wave energy of the Pacific Ocean. Adaptation strategies may include projects or comprise regulations, both of which would guide the County's land uses toward being more resilient.

Sea level rise adaptation will have to be implemented regionally, in partnership with multiple departments and adjacent jurisdictions. The County General Plan, the FEMA adopted Ventura County Multi-Hazard Mitigation Plan, the LCP, and capital improvement plans all need to be aligned to improve climate resiliency, set up funding mechanisms, and allow the County to develop its own vision for the future of unincorporated communities, infrastructure, natural and recreational resources. In some cases, sea level rise adaptation strategies could be implemented through the Planning Division's day-to-day development review that is conducted through the certified LCP, which sets standards of review and grants decision-making authority under the California Coastal Act to local jurisdictions. Other strategies represent case studies or pilot projects that would require pro-active coordination with other departments, organizations and funding sources yet to be identified. While this Adaptation Report does not provide the tools for a comprehensive approach to address sea level rise, when combined with the Vulnerability Assessment, these documents provide a foundation for sea level rise planning in Ventura County. It is a big first step to setting a community vision for priorities of coastal resources. A comprehensive approach to coastal resilience will need to be developed with dialog, communication, and additional feedback from stakeholders, decisionmakers, and State agencies such as the California Coastal Commission (Coastal Commission[1]).

Five case studies are provided in Section 3.2 of this Report. Each provides a framework for managing risk and taking action to minimize the immediate threat of coastal flooding and the long-term threat of sea level rise. The adaptation case studies focus primarily on strategies that apply to publicly owned assets and infrastructure, where the County has more authority. However, the strategies summarized throughout the Report include options that could apply equally to privately owned land or to publicly owned beaches and infrastructure. It's understood that collaboration with landowners and other regional and local stakeholders would be needed before adaptation approaches for privately held land could be developed or implemented.

A written narrative and a general implementation timeline are provided for each case study with proposed triggers for implementing the next phase of adaptation planning. A limited fiscal analysis of four of these case studies is included in Appendix B. These case studies are meant to allow for dialogue and to illustrate the trade-offs of waiting versus more actively addressing sea level rise now. They are not intended to prescribe a specific plan of action, but rather are intended to inform decisionmakers on the types of responses available. Future LCP amendments, proposals, feasibility studies and project-level analysis would be required before employing the proposed adaptation strategies.

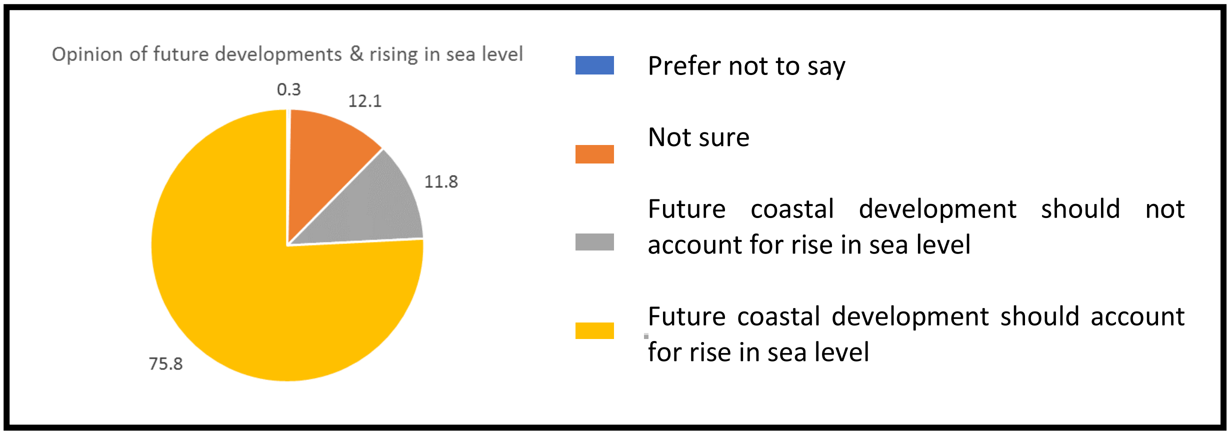
1.1 Advanced Planning for Sea Level Rise

Coastal resource protection in California is instituted through decades of local, State and federal initiatives. For over 40 years the Ventura County General Plan has directed polices that "protect and conserve coastal beaches and sand dunes."[2] The General Plan update that is currently underway will likely continue to direct the County to conserve coastal resources, and the public supports these efforts. A public survey conducted for the General Plan update in 2017 estimated that over 75% of residents believe that future coastal development should account for sea level rise (Figure 1-1). Thus, a clear majority of residents support an adaptive approach to sea level rise.

[1]While the 12 voting members of the California Coastal Commission ultimately decide whether to certify new LCP policies, most coordination occurs with Coastal Commission staff at the local office. This reference applies to the local Coastal Commission staff.

[2]Ventura County General Plan, Goals Policies and Programs, 1.10.1 Goal.

Figure 1-1. Public opinion on how to respond to climate change and prepare for sea level rise.



While public perception favors planning for sea level rise, the County's approach to adaptation requires making difficult decisions. Some of these decisions could reduce coastal hazards today, and others could require planning for actions that extend beyond the year 2040 horizon of the General Plan Update. Science tell us that change along the county's coastline is inevitable, and while there is still time, failure to be proactive is likely to result in more damages and increase hazards. The Vulnerability Assessment and Appendix B demonstrate that there are high economic and safety risks associated with not planning for increasing coastal hazards. Over the next few generations, the Pacific Ocean will encroach inland and it will become increasingly difficult to maintain the current shoreline. To answer the question, "How to plan for sea level rise?" the challenge will be for Ventura County to engage in proactive, thoughtful planning to identify manageable solutions that minimize risks at the appropriate times.

1.2 Report Goals and Deliverables

This Report identifies strategies that are based on the results of the Vulnerability Assessment and were selected after initial coordination with other agencies. The strategies include analysis and recommendations from the consultant for this project, Revell Coastal LLC., and are based on input from Caltrans, the State Department of Parks and Recreation, California Coastal Commission staff, the Natural Resources Working Group, and County agencies including the Agricultural Commissioner's Office, the Watershed Protection District, the Harbor Department, the Transportation Division, and the Environmental Health Division. Public comments received in response to the Vulnerability Assessment were also integrated into the strategies that are covered in the most detail. Most of the public comments were received from coastal residents who expressed support for sand retention strategies and generally opposed any new restrictions on the use of shoreline armor.

This Report will be used to draft potential sea level rise polices for review and comment by the Board of Supervisors. Adoption and certification of comprehensive sea level rise policies in the County's Local LCP will require future public hearings before the Planning Commission, Board of Supervisors, and ultimately the Coastal Commission before they become effective. Sea level rise policies and programs are also being included in 2040 General Plan Update.

Adaptation strategies for the Channel Islands Harbor are generally not included in this report because, while the harbor is owned and operated by the County, it is included in the City of Oxnard's LCP and is regulated through a separate Coastal-Commission-approved Public Works Plan. Nonetheless, some of the strategies highlighted in this Report require adaptation efforts in coordination with the Harbor Department and the City of Oxnard to protect unincorporated areas.

1.3 Adaptation Planning Guidance

This Section describes State guidance for sea level rise planning that can be used to develop County policies relative to sea level rise. The California Coastal Commission and the Ocean Projection Council have finalized sea level rise guidance documents that are being used by local jurisdictions. These documents include the "Coastal Commission Residential Adaptation Policy Guidance" (2018), "Coastal Commission Sea Level Rise Policy Guidance" (2015/2018), and the "State of California Sea-Level Rise Guidance" (2018). The guiding principles and preferred adaptation approaches are listed below. This information is useful for developing principles for the County's adaptation strategies.

California Coastal Commission Sea Level Rise Policy Guidance (2015/2018)[3]

In 2015 the California Coastal Commission adopted its first *Sea Level Rise Policy Guidance document.* This document provides an overview of the best available science on sea level rise for California and a recommended methodology for addressing sea level rise. In 2018, the Coastal Commission adopted a Science Update to the *Sea Level Rise Policy Guidance*. The science-focused changes reflect recent scientific studies and statewide guidance to further the understanding of sea level rise projections relevant to California. Though the Sea Level Rise Policy Guidance is not tailored to local conditions, it contains 20 guiding principles for addressing sea level rise in the coastal zone that fall into four general categories:

1. Use science to guide decisions;
2. Minimize coastal hazards through planning and development standards;
3. Maximize protection of public access, recreation, and sensitive coastal resources; and,
4. Maximize agency coordination and public participation.

These guiding principles are derived from the requirements of the Coastal Act and complement the priorities outlined in the State of California's climate adaptation strategy, the *Safeguarding California plan: 2018 Update*.[4]

State of California Sea-Level Rise Guidance (2018)[5]

The 2018 California Natural Resources Agency and Ocean Protection Council *State of California Sea-Level Rise Guidance* includes eight preferred sea level rise planning and adaptation approaches:

1. Adaptation planning and strategies should prioritize social equity, environmental justice and the needs of vulnerable communities.
2. Adaptation strategies should prioritize protection of coastal habitats and public access.

[3] California Coastal Commission; Sea Level Rise Policy Guidance; November 2018; available at: https://www.coastal.ca.gov/climate/slrguidance.html
[4] California Natural Resources Agency; Safeguarding California Plan; January 2018, available at: http://resources.ca.gov/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf
[5] California Natural Resources Agency and Ocean Protection Council; State of California Sea Level Rise Guidance; 2018; available at: http://www.opc.ca.gov/updating-californias-sea-level-rise-guidance/

3. Adaptation strategies should consider the unique characteristics, constraints and values of existing water-dependent infrastructure, ports and Public Trust uses.
4. Consider episodic increases in sea level rise caused by storms and other extreme events.
5. Coordinate and collaborate with local, state and federal agencies when selecting sea level rise projections; and where feasible, use consistent sea level rise projections across multi-agency planning and regulatory decisions.
6. Consider local conditions to inform decision making.
7. Include adaptive capacity in planning and design.
8. Assessment of risk and adaptation planning should be conducted at community and regional levels, when possible.

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2. EXISTING SETTING AND POTENTIAL IMPACTS

The Ventura County Local Coastal Program (LCP) regulates land uses on approximately 29 miles of coastline with tremendous coastal resources. These resources include 7.5 linear miles of public beaches, dozens of public coastal access points, over 400 acres of County and State Parks, and critical infrastructure such as State highways and the Point Mugu Naval Air Weapons Station.[6] There are small residential communities that host about 4,700 residents,[7] 5,900 acres of agricultural fields,[8] and the Navy employs over 18,000 residents.

Natural resources within the coastal zone include sandy and rocky beaches, kelp and surfgrass beds, tidepools, coastal bluffs, dunes, estuaries, wetlands, riverine environments, and all the species that these habitats support. The coastal zone also curves inland to include the Santa Monica Mountains National Recreation Area, home to over 1,500 plant and animal species. Wide sandy beaches support a sand dune ecosystem at Hollywood Beach, and a network of interconnected coastal back dunes, estuaries, freshwater wetlands and creek/river ecosystems reside among the three major tributaries of the Ventura River, Santa Clara River, and Calleguas Creek. Over time, the wetlands at Ormond Beach could also be restored, adding more valuable habitat to the unincorporated area.[9]

While there are exceptional coastal resources in Ventura County, coastal hazards have historically left an imprint and resulted in over 18 miles of shoreline protective devices. This amounts to about 17% of the existing shoreline armor along the entire State of California.[10] According to the Vulnerability Assessment, this shoreline armor will begin to be persistently flooded when sea level rise reaches about 5 feet in additional height, but before that occurs, storm waves combined with lesser amounts of sea level rise will cause waves to overtop the armor and exacerbate the coastal hazards that have historically occurred.

The County has high rates of subsidence and uplift, which could increase erosion rates in mountainous areas as well as inundation risk in low-lying areas. There is approximately 2.0 millimeters per year (mm/yr) of uplift of the Western Traverse Mountains on the North Coast, and this exceeds the current rate of sea

[6] The Point Mugu Naval Air Weapons Station is physically located within the unincorporated coastal zone, but since it is a federal facility its land uses are not regulated by the County's LCP.
[7] The population estimate includes Census blocks located along the unincorporated area coastline that are within 500 feet of the coastal zone. In some cases, the blocks that are included extend further inland. For more on the methodology, see Appendix C in the Vulnerability Assessment (Vulnerable Populations).
[8] This figure is based on agricultural areas evaluated in the Vulnerability Assessment, which include some agricultural uses that are located outside of the coastal zone.
[9] Currently there are only about 13 acres of unincorporated wetland area at Ormond Beach, excluding the ponds for the Ventura County Game Preserve and excluding the wetlands at the Naval Air Weapons Station.
[10] While estimates vary, the California Beach Restoration Study, (Griggs et al., 2002) estimated there are 102 miles of armor on California's coastline. Unincorporated Ventura County has about 18 miles of armor.

level rise, which is about 1.01 mm/yr to 1.51 mm/yr[11] according to local tide gauges. However, by 2100 the rate of sea level rise is expected to reach 20 mm/yr. The rate of uplift is less for the South Coast and the Santa Monica Mountains, which are estimated to be rising by about 0.5 mm/yr.[12] The Central Coast faces subsidence rate of about 1.33 mm/yr due to groundwater extraction, oil and gas production, and tectonic activity.[13]

This Section briefly summarizes the key findings from the Vulnerability Assessment that was completed in December 2018 for the North, Central, and South Coasts (Figure 2-1). The Vulnerability Assessment summarized which coastal resources in the unincorporated area could be affected by up to approximately 5 feet of sea level rise, by about year 2100.[14] The resource sectors that were evaluated in the Vulnerability Assessment included land use parcels and structures, agriculture, wastewater infrastructure, stormwater infrastructure, water supply infrastructure, public access and recreational facilities, natural resources, roads and parking, oil and gas infrastructure, hazardous material sites, and critical facilities such as fire stations and wireless communication facilities. These resource sectors were mapped using Geographic Information Systems software (GIS) along with modeling results from the Coastal Resilience Sea level Rise Model showing the extent of coastal erosion, coastal flooding, tidal inundation, and fluvial (river) flooding at 8 inches, 16 inches, and 58 inches of sea level rise. More information on the sea level rise modeling methodology can be found in Section 4 of the Vulnerability Assessment.

Throughout the remainder of this Section (Subsections 2.1 through 2.3) the results from the Vulnerability Assessment and the Coastal Resilience model are also compared to the results of the Coastal Storm Modeling System (CoSMoS) sea level rise model in order to provide a broad context of potential exposure according to the best available sea level rise science. The CoSMoS model projections do not precisely match the 8-inch, 16-inch, and 58-inch amounts of sea level rise used in the Coastal Resilience model and the Vulnerability Assessment, so the closest equivalent amounts of 9.6 inches, 19.2 inches, and 58.8 inches were analyzed in CoSMoS, but are reported here as being approximately 8-inches, 16 inches, and 58 inches to help clearly convey the general results of the analysis to the reader. The proceeding section, Section 3, presents possible adaptation strategies for the exposure areas that are identified in this Section and in the Vulnerability Assessment, followed by a few example case studies that describe how they may be used at local sites.

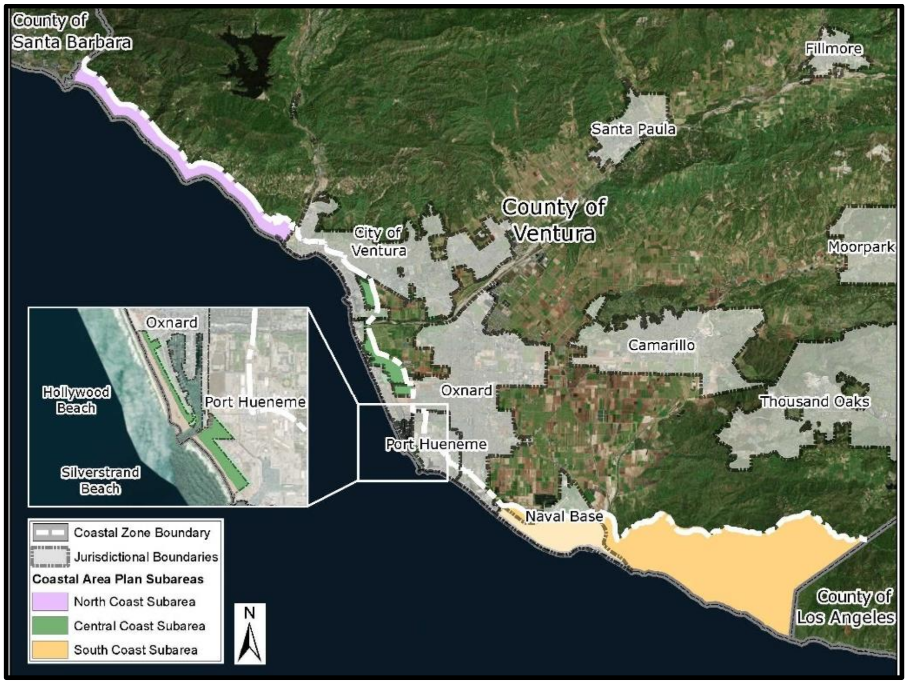
[11] Hammond, W. C., Burgette, R. J., Johnson, K. M., & Blewitt, G.; Uplift of the Western Transverse Ranges and Ventura area of Southern California: A four-technique geodetic study combining GPS, InSAR, leveling, and tide gauges; 2018. *Journal of Geophysical Research: Solid Earth*, 123, 836– 858.

[12] Meigs, A. J., Brozović, N., & Johnson, M.; Steady, Balanced Rates of Uplift and Erosion of the Santa Monica Mountains, California; 1999; *Basin Research*, 11(1), 59-73.

[13] United Water Conservation District; Preliminary Evaluation of Impacts of Potential Groundwater Sustainability Indicator on Future Groundwater Extraction Rates –Oxnard Plain and Pleasant Valley Groundwater Basins; 2017.

[14] According to the State of California Sea Level Rise Guidance 2018 Update, there is between a 0.5% to 5% probability that 5 feet of sea level rise will occur by the year 2100, based on the high emissions scenario.

Figure 2-1. County of Ventura, Coastal Area Plan, North, Central, and South Coast Subareas that are referenced in the organization of this Report.



2.1 North Coast

This Section summarizes the Vulnerability Assessment results for the North Coast area of the County (Figure 2-1) and describes how services could be affected without adaptation planning for sea level rise.

Existing Conditions and Community Narrative

The North Coast spans 12 miles from the northern County line at Rincon Point southward to the Ventura River. It encompasses coastal bluffs, a portion of the Santa Ynez Mountains, narrow sandy beaches, rocky tidepools, small creeks, and an estuary. Approximately 90% of the area inland of Highway 101 is open space or agriculture. Most of the land consists of large parcels of 20 to 40 acres or more, but residential neighborhoods along the coast have single-family homes on much smaller parcels. Six residential and two industrial "existing communities" are located on the North Coast. Oil wells and related production facilities are scattered throughout the area. US Highway 101 and the tracks of the Union Pacific Railroad wind along the narrow strip of land at the base of the mountains. Portions of the North Coast are set aside for recreation. Emma Wood State Beach, Hobson County Park, Faria County Park, and the Rincon Parkway provide opportunities for camping and beach access.

The North Coast has historically had few beaches due to the steep topography and obtuse angles between the shoreline and northerly waves and winds that drive strong downcoast currents and carry sand to the Central Coast (Photo 2-1). The North Coast beaches include naturally occurring cobble, tidepools, and sandy areas that fluctuate with the seasons. These beaches tend to accrete sand in the summer and fall months, then erode during winter storms (Photo 2-2). With the effects of sea level rise, the North Coast beaches will increasingly be submerged during high tides, particularly during the fall and winter.

Photo 2-1. This image of Old Coast Highway in 1912, with Rincon Point on the horizon, suggests that historically there was very little beach width along this stretch of the North Coast.

Photo 2-2. Difference in beach width at Solimar between October 2017 (left) and April 2018 (right).

Highway 101 on the North Coast is a critical transportation corridor, providing the only high-speed route to northern California besides Interstate 5. Pacific Coast Highway, sometimes referenced as "Old Coast Highway" and the "Rincon Parkway" is the predecessor of Highway 101, and today it is used primarily for access by beach visitors and local residents. About 750 residents live on the North Coast and a substantial number of these residents could be particularly vulnerable to hazards during severe storm events. Approximately 25% of the residents are seniors (65 and over), 35% are renters, and 10% are Hispanic.[15] The North Coast attracts many beachgoers and has popular surf breaks that beckon beginner-level surfers during the gentle waves of the summer, and experienced surfers when the large West/Northwest swells hit the coast in the winters. Public beaches and the shoreline constellation of County and State parks attract over one million visitors annually. Together, Hobson and Faria County Parks, the Rincon Parkway, and Emma Wood State Beach offer public parking and oceanside campsites, with the capacity to host over 500 tent campers and recreational vehicles. Lastly, the relatively new Ralph Fertig Memorial Bike Path offers 4 miles of spectacular Class I Coastal Trail along the North Coast (Photo 2-3).

Photo 2-3. Ralph Fertig Memorial Bike Path

Natural resources along the County's North Coast include kelp and surfgrass beds that support local fisheries, resource-rich tidepools, and seasonally narrow sandy beaches that support foraging shorebirds and spawning California grunion in the summer and fall. A small estuary is located at the mouth of Rincon Creek that historically supported Southern steelhead trout. It is also surrounded by trees that may provide Western monarch butterfly habitat.

Summary of Vulnerabilities

Using the Coastal Resilience model, the Vulnerability Assessment identified the areas discussed below that may be exposed along the North Coast. These areas of potential exposure were also compared to the CoSMoS modeling results that were recently published for Ventura County.[16] Locations that are predicted to be exposed to tidal inundation are identified first in order to strategically focus on the effects of sea level rise, although the Vulnerability Assessment showed that more areas could be impacted when coastal storms combine with rising tides.

[15] For more information on the demographic composition of the North Coast, read the VC Resilient Coastal Adaptation Vulnerability Assessment Report Appendix C (Vulnerable Populations).
[16] CoSMoS modeling results can be viewed through the "Flood Map" tab at http://data.pointblue.org/apps/ocof/cms/

Tidal Inundation Vulnerabilities

Except for Rincon Point, all 12 miles of the North Coast are presently armored with rock revetments and vertical seawalls. The beaches located between the sea and these devices will be the North Coast's most vulnerable resource over the next few decades. With time, small "pocket" beaches will be submerged more frequently and for longer periods of time, eventually becoming inaccessible for recreational activities, foraging shorebirds, and spawning grunion.

Tidal inundation at Rincon Point has the potential to directly affect nearby residences and the biological habitat within the small estuary located at the mouth of Rincon Creek (Figure 2-2). Some sea level rise studies have suggested that marsh habitat within small creek estuarine systems will be susceptible to conversion into subtidal habitat due to a lack of a transition zone which is most often caused by steep topography or development (as in the case of Rincon Creek).[17] These changes are likely to significantly affect plant and animal habitat niches within the estuary. If the flood regime is high enough, a potential benefit of an increase in tidal inundation within the Rincon estuary is that it may reconnect the aquatic ecosystem in the estuary to the upper portion of the creek, which is blocked by a raised spillway associated with Highway 101.[18]

Figure 2-2. Tidal inundation with about 5 feet of sea level rise at Rincon Point according to Coastal Resilience (left) and CosMoS (right).

Like the Coastal Resilience model, the CoSMoS model shows most beaches on the North Coast as submerged with just 2.5 feet of sea level rise. Otherwise there are only subtle differences between the two model results for the North Coast until about 5 feet of sea level rise. In Figure 2-3 below, both models show that the rising tides begin to overtop the rock revetments at the Seacliff neighborhood and there is extensive flooding at Hobson County Park. In fact, Hobson County Park could have one of the first

[17] Doughty, C., K. Cavanaugh, R. Ambrose, and E. Stein; Sea Level Rise Impacts to Coastal Habitats in Southern California Estuaries; 2017; University of Southern California Sea Grant Traineeship Program Report. Pp.1-35

[18] This result is also dependent upon the sedimentation dynamics of the system and whether the mouth of the creek opens to the ocean.

revetments to be overtopped by rising tides, as the CoSMoS model reveals flooding beginning to occur on this site with 3.3 feet of sea level rise. The results showing tidal flooding with about 5 feet of sea level rise that begins to overtop the shoreline protective devices is also shown to a lesser extent at the Solimar, Faria, and Mussel Shoals neighborhoods. The County-owned Faria Beach Park is not as exposed to tidal flooding as Hobson Park, but any tidal flooding would be more extensive with the combined effects of coastal storms and erosion.

Figure 2-3. Tidal inundation with about 5 feet of sea level rise in Seacliff according to Coastal Resilience (left) and CosMoS (right). The green-colored areas are low-lying areas that could be flooded but are not connected to the shoreline or there is an obstacle blocking the flow.

Storm Flooding Vulnerabilities

The Vulnerability Assessment maps appear to show more severe effects than the maps shown in Figures 2-3 and 2-4 above because they show combined exposure from sea level rise and a 1% annual chance storm event. A 1% annual chance storm event could cause extensive damage to the North Coast, as similar storms have resulted in road closures and required emergency repairs (Photo 2-4). All existing residential communities located oceanside of Highway 101 are vulnerable to coastal storm hazards today. With sea level rise, the vulnerabilities increase gradually. With 16 inches of sea level rise, the strawberry fields inland of the Seacliff community become vulnerable to coastal storm hazards. With about 5 feet of sea level rise, coastal storms could impact the first row of houses located inland of Highway 101 in La Conchita.

The vulnerability of Rincon Point will increase if coastal erosion diminishes the cobble beach. Coastal storm and sea level rise effects at Rincon Creek are likely to cause an increase in pollution within the estuary if adjacent development is flooded. Storm damages and secondary effects such as pollution could also degrade or destroy trees along the shores of the estuary that may have historically had Western monarch overwintering roosts. Erosion could also expose cultural resources such as Native American historic villages, shell middens, and cemeteries, as this area has a high likelihood of containing archaeological resources.[19]

Services into the Future

Photo 2-4. Example of coastal flooding on Highway 101

How services are maintained in the North Coast will depend on the adaptation strategies employed by the County, resource managers, and residents. Under business as usual, clean-up and maintenance costs for coastal flooding will increase with time until persistent tidal flooding occurs. Nearly all development on the oceanside of Highway 101 is vulnerable to coastal storm hazards in the short term, and many areas on the oceanside of Old Coast Highway could be exposed to tidal flooding with greater than 5 feet of sea level rise in the long-term.

The tragic 2018 Montecito floods and debris flow demonstrated how the closure of Highway 101 would heavily impact the movement of goods and services within the region. There are over 11,000 daily commuters from Ventura into Santa Barbara County that would need to find alternative routes.[20] Many of these individuals work in service industry jobs such as at hotels and restaurants and would be disproportionately impacted by road closures due to sea level rise. Storm damage along Old Coast Highway could also have repercussions for the entire North Coast if erosion exposes a gas or oil line, ruptures a wastewater line, or damages an electric line.

Maintaining the services in the North Coast will rely largely on the resilience of infrastructure in the face of increasing coastal hazards. Highway 101, Old Coast Highway, and the Union Pacific Rail line are the backbone of the North Coast community. In particular, the response to sea level rise will depend on the strategy for Old Coast Highway, as it is seaward of the major roads and rail line, and it is associated with other infrastructure such as the underlying Service Area 29 sewer line, water lines, and overhead electricity lines. Hobson Park, Faria Park, the Rincon Parkway, and Emma Wood State Beach are all accessed via Old Coast Highway.

Inland of Old Coast Highway, most of the oil and gas pipelines run beneath Hobson Road and Frontage Road, and these roads generally lie within the Highway 101 or railroad right of way. The most vulnerable areas are oil lines along the inland side of Highway 101 south of Rincon Point, and oil and natural gas lines in areas where Hobson Road is near the sea, such as along the Faria and Solimar neighborhoods. There are also some gas lines on Frontage Road, which runs parallel to the rail line at Emma Wood State Beach. All of these segments are projected to be exposed to flooding during major storms, but as long as Old Coast

[19] Foster, John M.; RPA, President, Greenwood and Associates; personal communication on December 18, 2018. Also "Archaeological Sensitivity", Ventura County GIS Layer, Source: N. Nelson Leonar, III, Chief Archaeologist, Archaeological Survey, University of California, Los Angeles, July 14, 1973.

[20] Santa Barbara County Association of Governments; "State of the Commute", 2014. Many commuters had to find alternative routes during the Highway 101 closure following the Montecito floods.

Highway remains protected, the pipelines cannot be affected by erosion, which is the greatest threat that sea level rise presents to underground utilities.

Erosion was not modeled along the North Coast in the Vulnerability Assessment because the natural process is restricted by shoreline armor. But in addition to erosion concerns that could affect Rincon Point, erosion at Emma Wood near the County/Ventura City Boundary is an area of special concern due to the conglomeration of infrastructure passing through a shoreline area at the toe of bluffs that is as narrow as approximately 355 feet in width (Figure 2-4). Currently this area is protected by seawalls, and some need repairs. It would be in the interest of Caltrans, the Union Pacific, the Gas Company, the oil purveyors, and the County Water and Sanitation Department to assist State Parks in limiting potential erosion and maintaining or expanding the current shoreline width to protect this proverbial bottleneck from erosion and in order to maintain services.

Figure 2-4. A damaged seawall at Emma Wood State Beach protects a thin stretch of shoreline that includes the State Park access road, the rail line, Old Coast Highway, Highway 101, and power, oil, gas, and sewer lines. The bottleneck of infrastructure on a thin stretch of the shoreline is shown in the Google Earth image below.

Maintaining the services that allow the North Coast to retain its community character with increasing sea level rise and coastal hazards will require proactive adaptation planning to balance the recreational, residential, industrial, and other needs in this subarea. For example, the community at Rincon Point will require the development of an adaptation strategy that balances the residential use, recreational use (world class surf break/bike trail), and the ecosystem services provide by the natural resources. Predicting how the surf break or estuary will change as the sea rises requires a more detailed approach that includes monitoring and data collection.

The North Coast is nearly completely armored. The seawalls and revetments provide an important service but are in various conditions of repair. A uniform approach to armor could be added into the County's Coastal Zoning Ordinance, including design standards to minimize beach impacts after more study, and a common approach to mitigation, in order to provide more certainty until other long-term solutions are identified. Strengthening or elevating existing armor in one area could increase the exposure and impacts to surrounding areas. In many areas, sediment retention and beach nourishment could be considered alongside armoring options. Elevating buildings as they are redeveloped, either with pilings or uninhabitable ground floors, could be an alternative to more armor, but such actions have drawbacks; for example, they could result in dramatic differences in building heights, and gaps in shoreline armor can isolate the remaining armor and enhance the effects of erosion on downcoast development.[21] The constraints are many and alternatives are few as the North Coast is in a narrow stretch of land between the ocean and steep bluffs. Generally, the existing armor is projected to withstand about 5 feet of sea level rise, but its protective utility will be diminished as coastal storms increase in predicted severity and waves more frequently overtop the structures.

2.2 Central Coast

This Section summarizes the Vulnerability Assessment results for the Central Coast area of the County (Figure 2-1) and describes how services could be affected without adaptation planning for sea level rise.

Existing Conditions and Community Narrative

The Central Coast begins along the Santa Clara River and ends at the southern border of the City of Oxnard. The Cities of Ventura, Oxnard and Port Hueneme, as well as the Navy, share 16.5 miles of coast with agriculture, beaches, sand dunes, fresh and saltwater marsh ecosystems, two power plant facilities, a harbor and a port, and a variety of heavy industry and oil operations. Unincorporated lands within the Central Coast are varied. Several agricultural parcels are surrounded by the City of Ventura just north of the Santa Clara River. Further south, inland from McGrath Lake and Mandalay Beach, are approximately 1,400 acres of unincorporated land used primarily for agriculture with some oil production. Edison Canal is located among dunes and agriculture and extends about two miles from the Channel Islands Harbor to where it was used to cool the turbines at the now-shuttered Edison Mandalay Generating Station in the City of Oxnard.

To the north and south of the mouth of the Channel Islands Harbor lie the most densely populated unincorporated residential neighborhoods along the County's coast: Hollywood Beach and Silverstrand. Limited commercial uses and numerous stub-end streets that provide public beach access characterize these beach communities. The City of Oxnard and the Port of Hueneme border these beach communities on three sides. Jurisdiction over the Channel Islands Harbor is shared between the County Harbor Department and the City of Oxnard.

The Central Coast communities of Hollywood Beach and Silverstrand are home to about 4,700 residents and a substantial number of these residents could be particularly vulnerable to hazards. Approximately 14% of residents are seniors (65 and over), 48% are renters, and 14% are Hispanic.[22] Silverstrand is also one of the most popular beaches in the County and has a yearly attendance of about 410,000 visitors.

The natural resources within the Central coast were formed and influenced by the hydrological forces of the Santa Clara River on the Oxnard floodplain. The remnants of a broad barrier beach-dune ecosystem which once spanned from the Santa Clara River to Point Mugu still remains inland of McGrath Lake and Mandalay Shores. Hollywood Beach also has dunes near the harbor sand trap. These beach-dune systems

[21] US Army Corps, Coastal Engineering Manual- Part IV, Table V-3-3, Assessment of Commonly Expressed Concerns Related to Coastal Armoring (Dean 1987) "If an isolated structure is armored on an eroding beach, the structure will eventually protrude into the active beach zone and will act to some degree as a groin, interrupting longshore sediment transport and thereby causing downdrift erosion."

[22] For more information on the demographic composition of the Central Coast, read the VC Resilient Coastal Adaptation Vulnerability Assessment Report Appendix C (Vulnerable Populations).

were once interconnected to the coastal back dunes, estuaries, freshwater wetlands and creek/river ecosystems located along the Ventura and Santa Clara Rivers, Calleguas Creek, and the Ormond beach area. Numerous rare and sensitive species are dependent upon these habitats such as the California grunion, the endangered Ventura marsh milk vetch, the iconic Western monarch butterfly, California least tern, red sand verbena, and the Western snowy plover, and others.

Summary of Vulnerabilities

Using the Coastal Resilience model, the Vulnerability Assessment identified the areas discussed below that may be exposed on the Central Coast. These areas of potential exposure were also compared to the CoSMoS modeling results that were recently published for Ventura County.[23] Locations that are predicted to be exposed to tidal inundation are identified first in order to strategically focus on the effects of sea level rise, although the Vulnerability Assessment showed that more areas could be impacted when coastal storms combine with rising tides.

Tidal Inundation Vulnerabilities

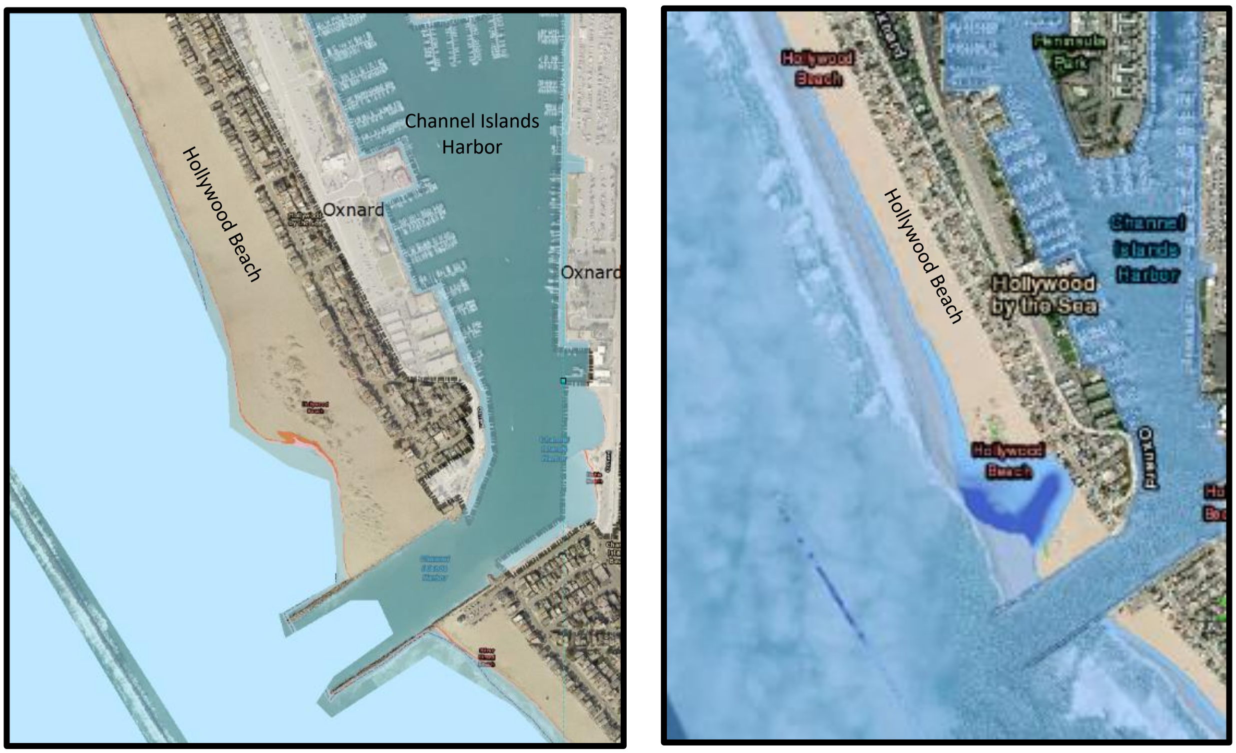
Compared to the North and South Coasts, the unincorporated coastal areas in the Central Coast are projected to be the most extensively affected by tidal inundation with 5 feet of sea level rise, including the Hollywood Beach and Silverstrand communities that are immediately adjacent to the ocean. These two communities boast the widest beaches on the unincorporated coast, approaching 1,000 feet in width near the dunes at Hollywood Beach, yet the dunes at Hollywood Beach are an area that is vulnerable to tidal flooding with only 8 inches of sea level rise (Photo 2-5). The CoSMoS model shows that with about 8 inches of sea level rise, the dune flooding may begin to reach some shoreline homes along Ocean Drive, while the Coastal Resilience model shows incremental additional dune flooding with 8 and 16 inches of sea level rise (Figure 2-5). The differences in the modeling results are likely due to fluctuations in the amounts of sand in this area, as it functions as a sand trap and is periodically dredged.

Eight inches of sea level rise would expose breeding habitat for birds such as the Western snowy plover and California least tern, who select wide sandy beaches to nest. Other species of plants and animals found in sand dunes, such as the red sand verbena, beach evening primrose, and the globose dune beetle, will also be impacted by the reduction of foredune habitat. California grunion are not likely to be significantly affected if sandy areas above the high tide line are available for the fish to spawn. However, the likelihood of trampling or damaging grunion eggs and embryos increases as beach widths narrow.

[23] CoSMoS modeling results can be viewed through the “Flood Map” tab at http://data.pointblue.org/apps/ocof/cms/

Photo 2-5. King tide flooding of sand dunes at Hollywood Beach on December 22, 2018 (source: Eugene Peck)

Figure 2-5. Tidal inundation with about 8 inches of sea level rise at the sand trap and dunes at Hollywood Beach according to Coastal Resilience (left, shown in orange color) and CosMoS (right).



With about 5 feet of sea level rise, Figure 2-6 shows tidal flooding from the Channel Islands Harbor begins to spill into the residential and commercial areas of Hollywood Beach and Silverstrand. At Hollywood Beach, both sea level rise models show extensive tidal flooding at the end of the peninsula. The CoSMoS model also shows extensive flooding of Ocean Drive, Sunset Lane, connector streets, the elementary school, and some residential development located along those roads.

Figure 2-6. Hollywood Beach tidal inundation with about 5 feet of sea level rise as modeled by Coastal Resilience (left) and CoSMoS (right).

The Silverstrand neighborhood is a low-lying area that is vulnerable to tidal inundation. In between 16 inches and 5 feet of sea level rise CoSMoS reveals that rising tides breach the shores of Hobie and Kiddie Beaches in the Harbor and begin to inundate residential areas as well as Port Hueneme (Figure 2-7). When the sea level rises by 5 feet, both models show in Figure 2-8 that the flooding will extend into a large plume of tidal inundation that impacts Silverstrand and much of the Port.

Figure 2-7. Silverstrand area tidal inundation with about 3.3 feet of sea level rise as modeled by CoSMoS. The green areas represent low-lying areas that could flood but flooding is obstructed by obstacles such as a barrier or higher ground.

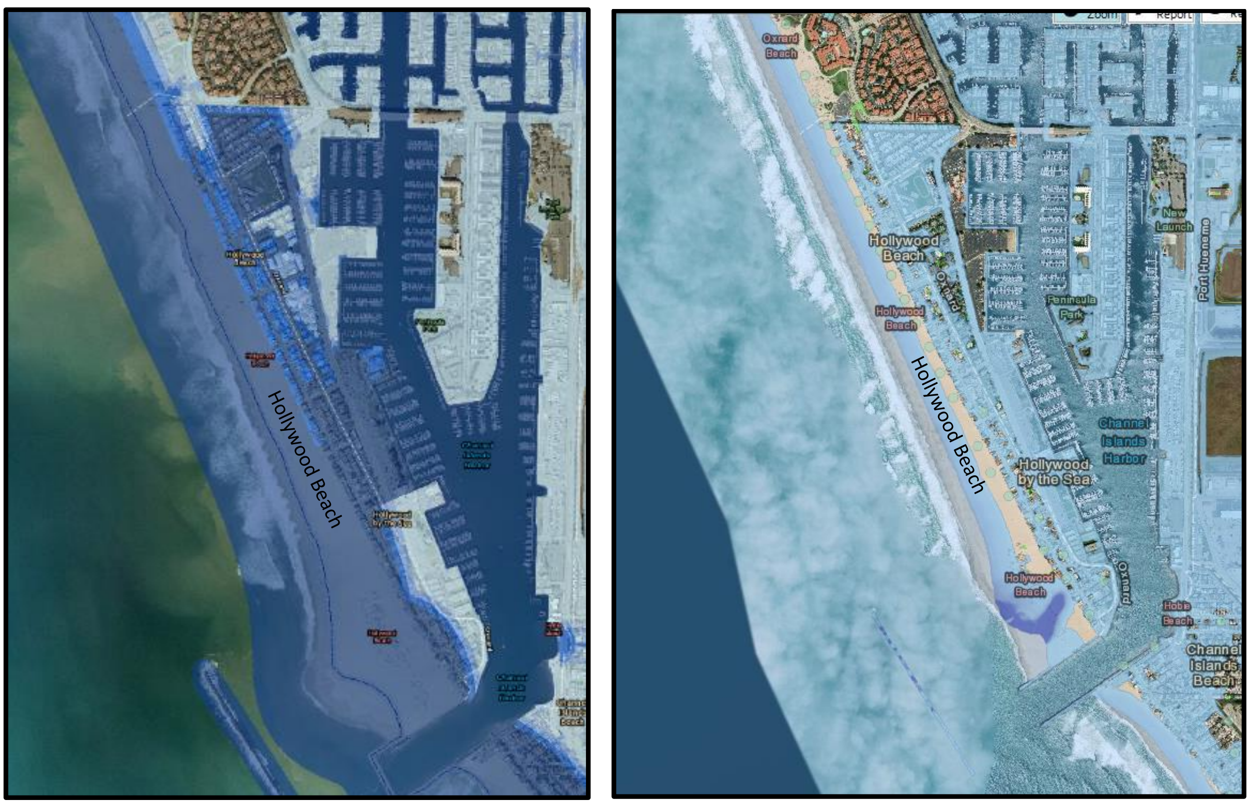
Figure 2-8. Silverstrand tidal inundation with about 5 feet of sea level rise as modeled by Coastal Resilience (left) and CoSMoS (right).

Storm Flooding Vulnerabilities

The Central Coast is highly vulnerable to coastal storm flooding and erosion due to the low elevations and gentle-sloping topography. All the areas described above would be exposed to more flooding when sea level rise is combined with a 1% annual chance storm that brings heavy rain and large waves.

At Hollywood Beach, the Coastal Resilience model shows storm waves combined with rising tides overtopping the beach, flowing through the developed areas of the peninsula, and into the harbor. However, the CoSMoS model shows that, except for the area near the dunes that could flood up to the back of the homes on Ocean Drive, the wide beach protects the neighborhoods from storm waves (Figure 2-9).

Figure 2-9. Flood Potential at Hollywood Beach with approximately 5 feet of sea level rise and a 1% annual chance storm. Note that the strip of sand on Hollywood Beach is the only unincorporated area that is not flooded in the CoSMoS model on the right. This is not a safe place for development but an opportunity for adaptation.



Storm flooding could also exacerbate the effects of rising tides at Silverstrand. Unlike Hollywood Beach, Silverstrand has some stormwater pumps to assist with drainage. But the County's storm water system does not extend to where improvements may be needed the most--the sea level rise models reveal a bottleneck where the Silverstrand tsunami evacuation route, at Hobie Beach, could be flooded for 12 or more hours with 8 inches of sea level rise and a 1% annual chance storm.[24] While the depth of flooding is difficult to clearly estimate using the models, it is likely to be more than a few feet in depth, which is an amount that is unsafe for civilian vehicle travel. This area of Victoria Avenue and Hobie Beach is under the City of Oxnard's and the Harbor Department's jurisdiction.

Along the Santa Clara River, fluvial river flooding caused by rain events can mix with rising tides and flood agricultural areas inland of McGrath State Park and around the McGrath Lake area. Similar fluvial flooding could occur along the Ventura River. All Central Coast habitats and species evaluated in the Vulnerability Assessment are vulnerable to extreme flood events, including USFWS designated critical habitats that support Ventura marsh milk vetch, Western snowy plover, tidewater goby, and the Southwestern willow flycatcher.

Services into the Future

Critical services such as utilities and emergency response may be disrupted during sea level rise and storm events. There is a slant-drilling oil facility downcoast from McGrath State Beach, oil wells in the Montalvo Oil Fields inland of McGrath, and agricultural lands that could be more frequently flooded over time, disrupting the oil supply and food production. In addition, floods are likely to spread containments such as oil, fertilizers, pesticides and other toxic chemicals associated with surrounding land uses into sensitive habitats, which may have a significant impact on plant and animal species' growth, fertility, and overall survivorship. The Vulnerability Assessment determined that the slant-drilling facility on the shore at McGrath is not vulnerable with up to 5 feet of sea level rise, but this facility and other land uses in the area are vulnerable to 1% annual chance storms that will become more frequent and hazardous when combined with the effects of sea level rise.

Adaptation approaches that the County takes upcoast from critical facilities in other jurisdictions could still affect those facilities. The power plants and wastewater treatment facilities are located nearby in the Cities of Oxnard and Ventura, and the Point Mugu Naval Air Weapons Station and Port Hueneme Base could all be affected. For instance, if additional sand retention devices were added to Hollywood Beach, and the accrued sand was removed and sent to other areas where there is beach erosion, then the downcoast areas of Hueneme Beach and the Navy Base at Point Mugu would receive less sand for their beaches.

At the neighborhood scale, local infrastructure, such as water and wastewater lines in Hollywood Beach and Silverstrand, would experience more frequent temporary service disruptions from flooding, but erosion could cause permanent damage (Photo 2-6). If the beaches are eroded, the foundations of the neighborhoods, set on ancient sand dunes and fill from the construction of the ports and harbors, could be eroded and undercut. The stormwater system could be affected if the outfalls are infiltrated by rising tides and storm waves. Adaptation may require electrical equipment to be elevated, pump capacity increased, and manholes waterproofed.

[24] According to the CoSMoS model, the extent of flooding predicted at Hobie Beach is about equal among scenarios showing approximately 8 inches of sea level rise with a 1% annual chance storm event (100-year storm event), and 16 inches of sea level rise with a 20-year storm event. A "20-year storm" event is expected to occur once in 20 years. There is a 5% chance that a 20-year storm will occur in any one year.

Photo 2-6. Oxnard Shores beach erosion following 1982-1983 El Nino winter storms (1984).

Transportation corridors in Hollywood Beach and Silverstrand also need adaptation planning, and coastal flooding could sever evacuation routes, particularly in Silverstrand Beach. The flooding that could occur at Hobie Beach (Photo 2-7) is a concern because the frontage road is also the only evacuation route in the area. The Tsunami Evacuation Route is shown in red in Figure 2-10 below. The County should coordinate adaptation planning for South Victoria Avenue with the Harbor Department and the City of Oxnard to reinforce this particularly vulnerable location. For example, the road could be elevated, or revetments or bulkheads could be added to reinforce the harbor shoreline.

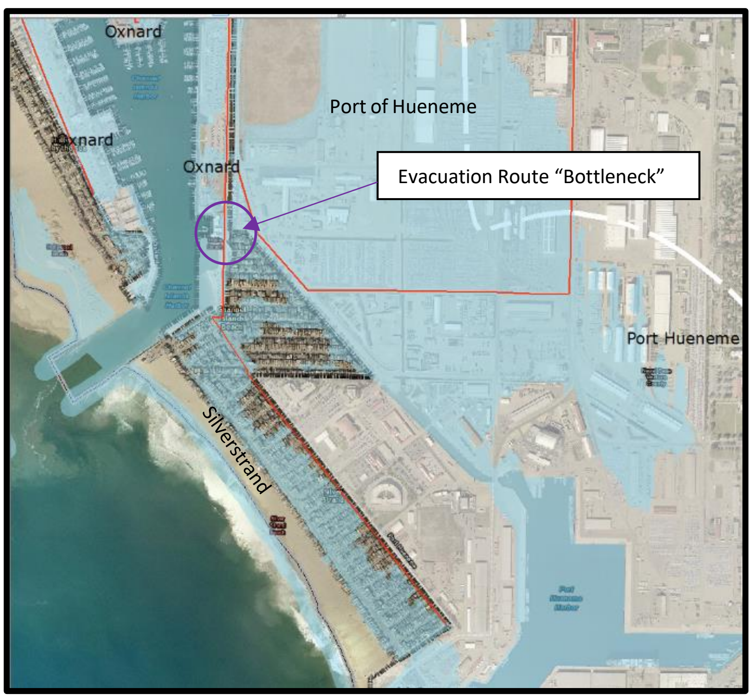


Figure 2-10. Flooding of tsunami evacuation route (shown in red) at Silverstrand with about 5 feet of sea level rise as modeled by Coastal Resilience.

Photos 2-7. Flooding at Hollywood Beach following March 2018 storm event (left) and elevated water levels at Hobie Beach near on Victoria Avenue during King Tides 2017 (right).

Continued coastal recreation on the County's most-visited beach, Silverstrand, and the largest coastal campground in the county, McGrath State Beach, will also depend on the adaptation approaches selected in coordination with other jurisdictions. The services that wide, accessible beaches provide to protect the Central Coast should not be taken for granted, and if the beaches are substantially eroded, or their respective elevations begin to be outpaced by rising tides, then beach berms or natural dune fields can help maintain these natural storm buffers while providing ecosystem services such as habitat and stormwater filtration. In the long-term, sand may become more valuable as the effects of sea level rise damage coastal areas. The Channel Islands Harbor was designed to provide a valuable service that traps and accumulates sand, and this sand may be increasingly sought after as the sea level rises.

2.3 South Coast

This Section summarizes the Vulnerability Assessment results for the South Coast area of the County (Figure 2-1) and describes how services could be affected without planning adaptation for sea level rise.

Existing Conditions and Community Narrative

The South Coast encompasses about 18,600 acres of some of the most striking and diverse coastal terrain in the County. Included along its 13.1-mile length are lagoons, coastal marshes, rocky intertidal zones and kelp beds, and approximately seven miles of the coastal Santa Monica Mountains. The South Coast's northern boundary is the Ormond Beach area that is located just north of the Point Mugu Naval Air Weapons Station, with the Los Angeles County line as the southern end point. Most of the federally-owned land in the County coastal zone is in the South Coast. The lagoon at the Navy Base at Point Mugu is fed by Calleguas Creek and combines with Ormond Beach to be one of the largest and most important estuaries and tidal marshes in Southern California. A small community area is located immediately north of the Ventura-Los Angeles County boundary along a narrow coastal terrace. The area, named Solromar, is designated as an "existing community".

At Ormond Beach, some heavy and light industrial development has occurred within the City of Oxnard, and there is a green waste processing facility in the unincorporated area, but most of the land remains open space and agriculture. Two private game preserves that date from the 1880s occupy much of the unincorporated land in the Ormond Beach area. The nearly 900-acres of private saltmarsh and freshwater ponds are used for duck hunting and nature viewing.

The South Coast has about 750 residents living mostly at Solromar and in scattered development up in the Deer Creek Road area of the Santa Monica Mountains. Some segments of the population that are potentially vulnerable to coastal hazards include the roughly 18% seniors (65 and over), 41% renters, and 17% Hispanics.[25] About 120 residents also live on agricultural lands in the Ormond Beach area. This community is composed almost entirely of Hispanic renters. Both Hispanics and renters were identified as populations that are particularly vulnerable to coastal hazards.

The South Coast is also home to Point Mugu State Park, featuring five miles of ocean shoreline, rugged mountains, coastal bluffs, sandy beaches, a few sand dunes, a small lagoon, and ephemeral streams. Thornhill-Broome Beach (Photo 2-8), Sycamore Cove, and La Jolla Group campgrounds of Point Mugu State Park are all located within the unincorporated coastal zone of Ventura County. Sycamore Canyon and La Jolla Canyon support valuable natural resources such as a small lagoon and monarch butterfly overwintering sites. The estuary within Sycamore Canyon is also designated as USFWS critical habitat for the tidewater goby. Thornhill-Broome and Sycamore Cove campgrounds have a total of 115 campsites and La Jolla Group campground can host a maximum of 50 visitors. Point Mugu State Park also has over 70 miles of hiking trails through the Santa Monica Mountains in Ventura County.

Other recreation areas include small beaches and day use parking areas at Mugu Rock, Yerba Buena Beach, and on the bluffs at the County Line/Leo Carrillo State Park area. Pacific Coast Highway (PCH) is an important transportation corridor on the South Coast, connecting Ventura and Los Angeles Counties. Most of the entire length of PCH is protected by rock revetments.

Photo 2-8. Thornhill-Broome Campground is Flooded Following a March 2018 Storm Wave Event.

[25] For more information on the demographic composition of the South Coast, read the VC Resilient Coastal Adaptation Vulnerability Assessment Report Appendix C (Vulnerable Populations).

Summary of Vulnerabilities

Using the Coastal Resilience model, the Vulnerability Assessment identified the areas discussed below that may be exposed along the South Coast. These areas of potential exposure were also compared to the CoSMoS modeling results that were recently published for Ventura County.[26] Locations that are predicted to be exposed to tidal inundation are identified first in order to strategically focus on the effects of sea level rise, although the Vulnerability Assessment showed that more areas could be impacted when coastal storms combine with rising tides.

Tidal Inundation Vulnerabilities

The lagoons and estuaries at Ormond Beach and Point Mugu are the most extensive South Coast areas vulnerable to tidal inundation. Predicting habitat changes within these ecosystems in response to sea level rise is difficult and depends upon several variables such as the rate of marsh sediment accretion, estuarine mouth dynamics, the amount of sea level rise, and extent of habitat fragmentation. Some beneficial changes within these habitats may occur, such as expansion of wetlands, but in most cases the current land uses surrounding these areas would not allow for wetland expansion. There is likely to be a loss of wetlands as sea level rise increases the depths and converts the habitat into mudflats and subtidal zones, causing a cascade of changes to wetland types and habitat niches. While the wetlands at Point Mugu are in the unincorporated area, they remain under federal jurisdiction and are managed by the U.S. Navy.

According to the Vulnerability Assessment, the Ormond Beach area is the largest area projected to be exposed to tidal flooding with as little as 8 inches of sea level rise, and over 1,000 acres of agriculture could be vulnerable when the sea level rises by 5 feet (Figure 2-11). The extent of flooding will depend upon strategies undertaken by the City of Oxnard, the US Navy, and the Ventura County Game Preserve to manage flooding of the estuaries and wetlands, as Ormond is part of the interconnected network of tidally-influenced ponds, channels, and canals in these areas.

The unincorporated areas near Ormond Beach primarily consist of agriculture, and landowners may elect to build berms that shield their land from tidal flooding that would otherwise degrade the soils. Other adaptation options include elevating the fields with sediment supplementation, protecting the area with large-scale levee improvements, use of nature-based horizonal levees, moving sensitive crops inland and planting salt-resistant crops in vulnerable areas, allowing wetland migration through voluntary managed retreat, or a combination of approaches. The County's Coastal Area Plan also discusses the potential for aquiculture in this area.

As an example, a green waste recycling facility in the area has built berms, but the devices are mostly configured along the ocean frontage of the property, and the two sea level rise models show that tidal flooding may still affect the site by flowing around the berms and through the site entryway, as shown occurring on the northeast corner of the site in Figure 2-12 below. There is, however, some discrepancy among the two models regarding the extent of potential tidal inundation at Ormond Beach. The Coastal Resilience model shows flooding beginning to occur at 8 inches (light blue) and 16 inches (dark blue), while the CoSMoS model suggests that the flooding may not occur until there is over 4 feet of sea level rise.

[26] CoSMoS modeling results can be viewed through the "Flood Map" tab at http://data.pointblue.org/apps/ocof/cms/

Figure 2-11. Potential tidal inundation in the Ormond Beach area with approximatley 5 feet of sea level rise as modeled by Coastal Resilience (left) and CoSMoS (right).

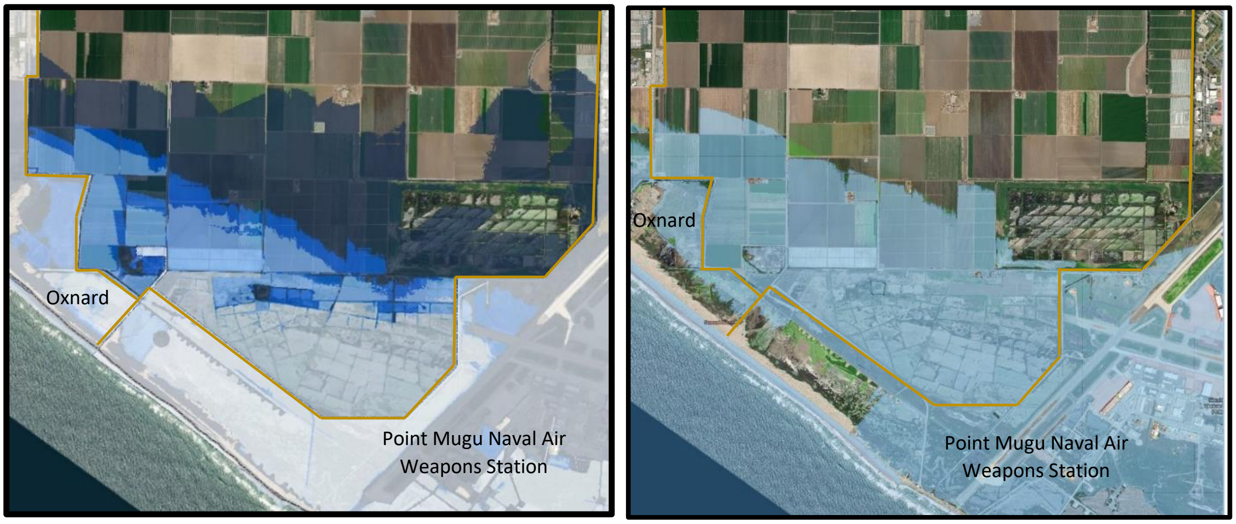
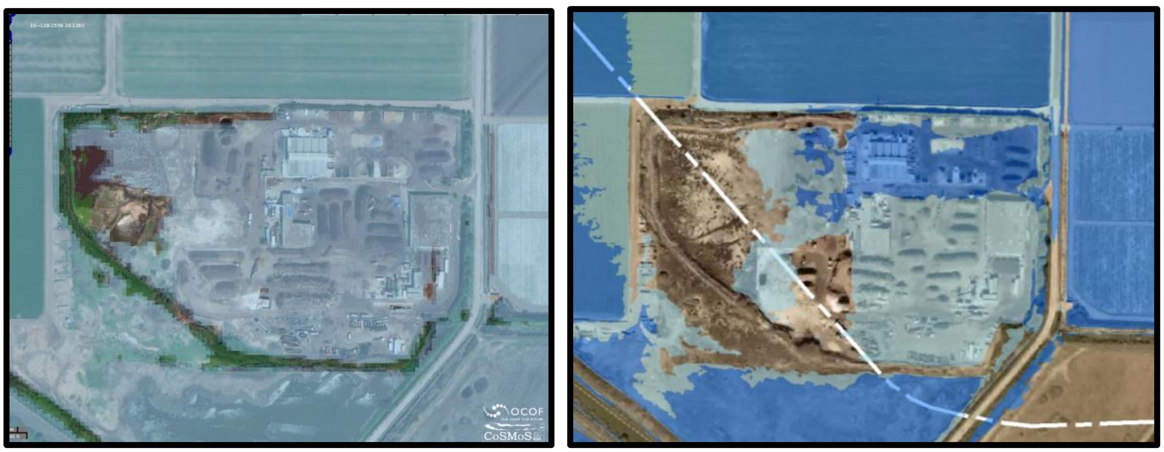
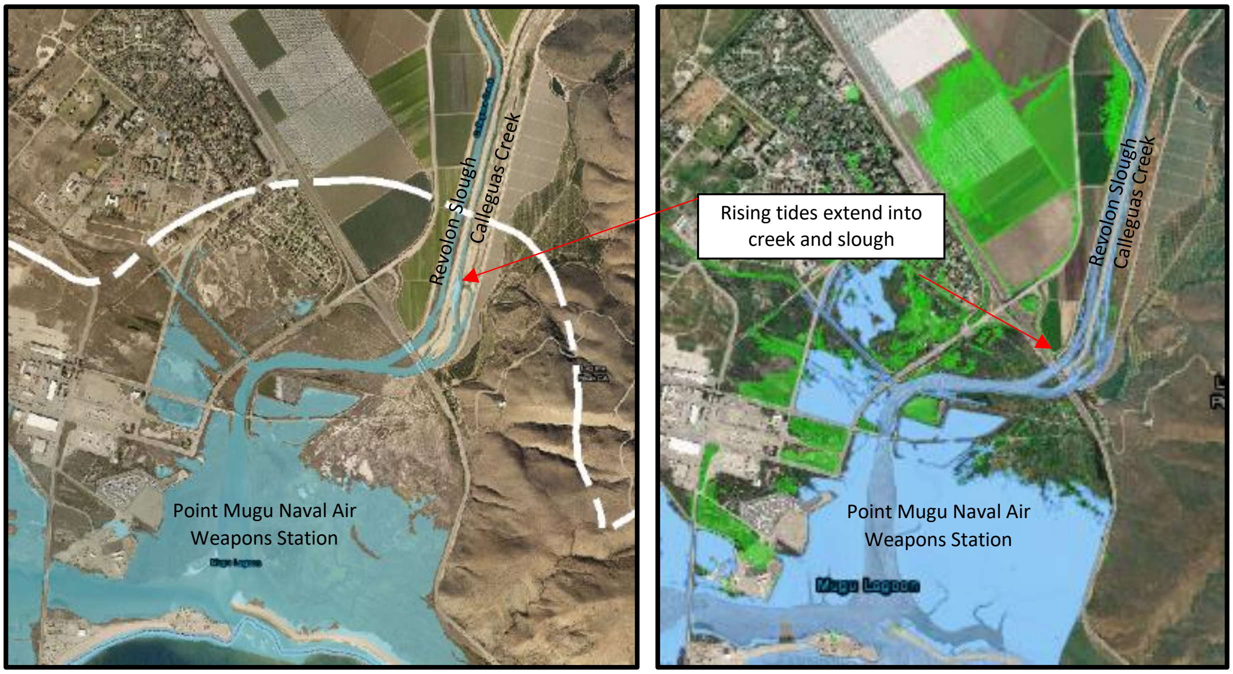


Figure 2-12. Earthen berms, such as the ones shown encircling most of the parcel below could be used to hold-off tidal flooding in agricultural areas located inland of Ormond Beach. Shown with approximately 5 feet of sea level rise as modeled by Coastal Resilience (left) and CoSMoS (right).



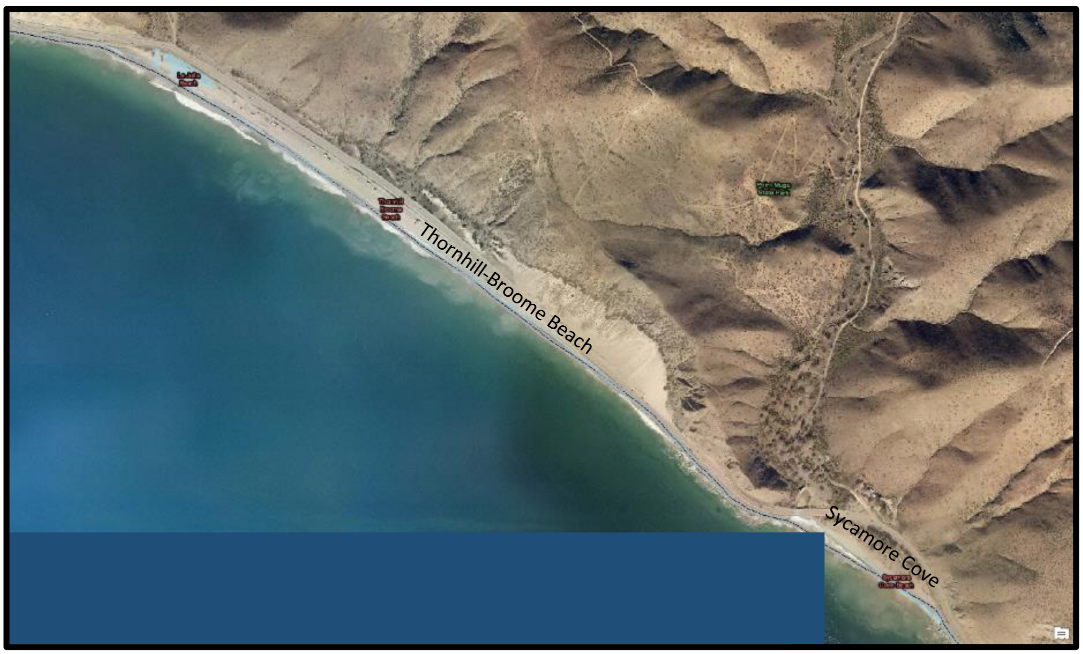
With 8 inches of sea level rise, County floodplain infrastructure at Calleguas Creek and the Revolon Slough are projected to be exposed to greater tidal inundation, surging up the channelized areas approximately 1-2 miles from the PCH bridge (Figure 2-13). The Revolon Slough is 10 feet lower in elevation than the Calleguas Creek at their confluence near PCH, and the slough could increasingly become a miles-long brackish canal. The drainage capacity of these facilities, which needs to be efficient during rain events, is likely to be substantially impeded during high tides.

Figure 2-13. Tidal inundation in the Mugu Lagoon area with approximately 8 inches of sea level rise, as modeled by Coastal Resilience (left) and CoSMoS (right). (**Note that CoSMoS hazard projections include a 5-10 year fluvial creek flood event in combination with the sea level rise.)**



The beaches in small coves along the South Coast are equally as vulnerable as the North Coast, with about 16 inches of sea level rise causing significant exposure at Thornhill-Broome Beach, Sycamore Cove, and Yerba-Buena Beach (Figure 2-14). These beaches are projected to be completely tidally inundated with about 5 feet of sea level rise. As with the North Coast, tidal inundation is expected to adversely affect historic spawning beaches of the California grunion. Changes to the biological conditions of the Sycamore Cove estuary will be similar to the estuary at Rincon Point discussed in the North Coast Vulnerabilities, although there is more potential for habitat migration because there is no spillway at Sycamore Cove.

Figure 2-14. Tidal inundation along the Thornhill-Broome Beach and Sycamore Cove area at Point Mugu State Park with approximately 16 inches of sea level rise according to CoSMoS (top). The Coastal Resilience model shows tidal inundation with about 5 feet of sea level rise (bottom).



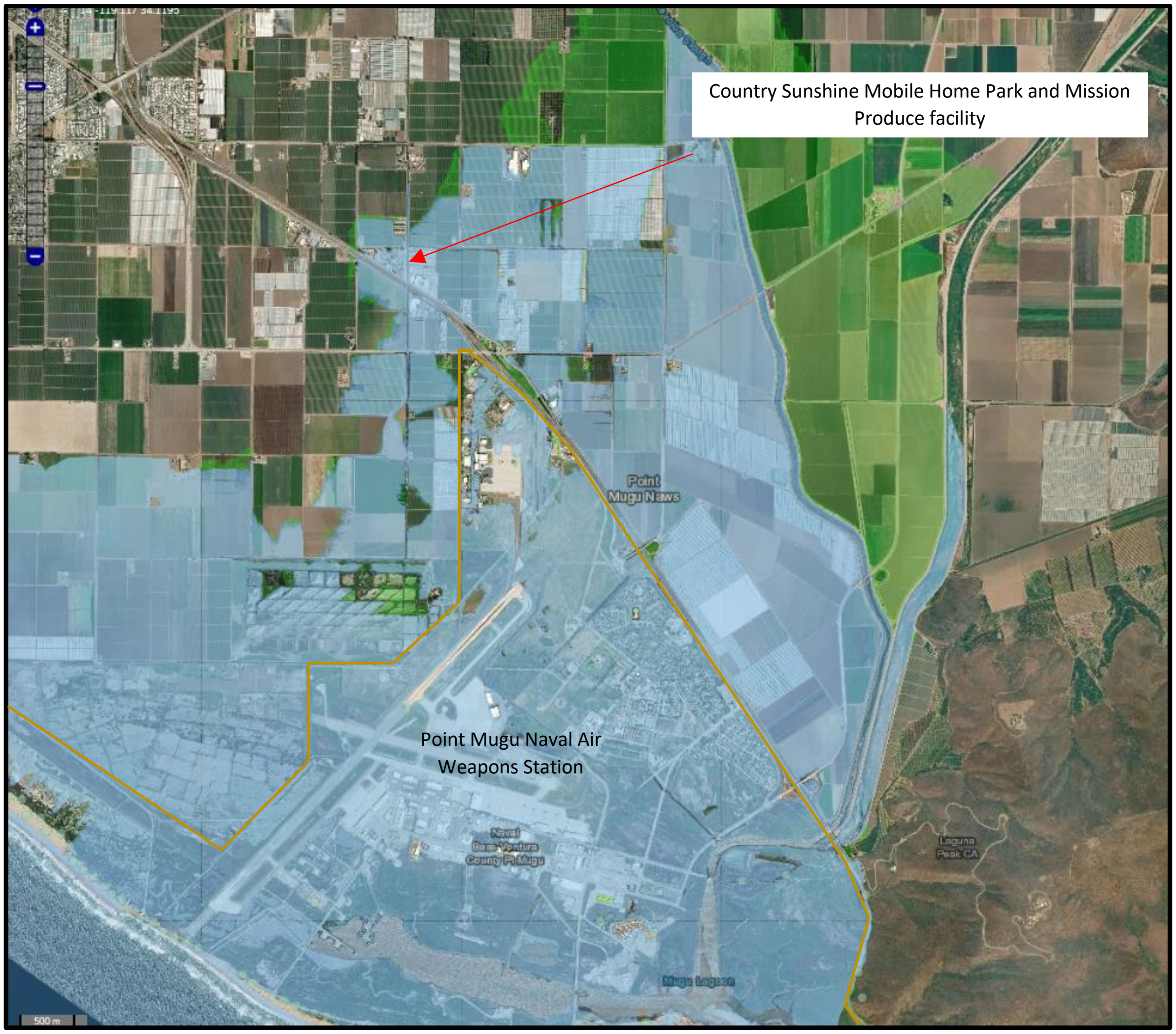
Near the Ventura-Los Angeles County line, coastal homes north of Yerba Buena Beach will have foundations and septic systems that are located on the seaward side of the property more exposed to episodic coastal erosion, wave flooding, and more routine tidal inundation. At the County line, approximately 24 acres of State Parks-owned property on coastal bluffs, with coastal access and public parking at Staircase Beach, are expected to experience more erosion with as little as 8 inches of sea level rise, and this erosion could undercut PCH with greater tides and large storms (Figure 2-15).

Figure 2-15. Tidal inundation along the Solromar Existing Community area with approximately 5 feet of sea level rise. The red lines represent potential bluff erosion. Results of sea level rise as modeled by Coastal Resilience (top) and CoSMoS (bottom).

Storm Flooding Vulnerabilities

The Ormond Beach, Calleguas Creek and Revolon Slough areas may become extensively flooded with a 1% annual chance storm combined with 5 feet of sea level rise (Figure 2-16). The surrounding agricultural land has the potential to function as temporary stormwater detention basin, but existing development that lies along PCH could also be exposed to stream flooding, such as the Country Sunshine Mobile Home Park (includes eight units), the Mission Produce processing facility, and nearly the entire Navy Base. A few existing farm residences will be susceptible to flooding, and saltwater will degrade the productive soil. If agricultural lands are protected by berms or traditional levees, these structures are likely to potentially cause flooding in other areas such as into Oxnard and upstream toward the City of Camarillo. Consideration could be given to employing horizontal levees and securing floodplain conservation easements that help to direct flooding into areas east of the slough, toward Calleguas Creek and the sparsely developed agricultural fields at the foot of the Santa Monica Mountains.

Figure 2-16. Flood Potential at areas inland of the Point Mugu Naval Air Weapons Station and west of Revolon Slough with approximately 5 feet of sea level rise and a 1% annual chance storm as modeled by CoSMoS.



Further south, rock revetments that protect PCH are currently vulnerable to erosion (Photo 2-9). Washouts along PCH are expected to increase as storm surge and sea levels continue to rise, escalating repair and maintenance costs and economically impacting residents and business owners dependent on the highway for access. With a 1% annual chance storm and 8 inches of sea level rise, over three miles of PCH on the South Coast is likely to be flooded. The length of exposed highway increases to over 10 miles with about 5 feet of sea level rise and a 1% annual chance storm.

Photo 2-9. Erosion at Thornhill-Broome Beach that occured on October 6, 2018 (Source: Caltrans).

All coves and pocket beaches below the Santa Monica Mountains are vulnerable to coastal storm flooding today. Fifteen first-come, first-serve campsites in the Thornhill-Broome Beach campground located in Point Mugu State Park are currently only open when weather and tides permit and are occasionally closed in the winter (Photo 2-8). The day use facilities and parking at Sycamore Cove become flooded with 5 feet of sea level rise. As the tides extend further into Sycamore Creek, coastal storm flooding may damage shelter trees at Western monarch butterfly roost sites.

In the Solromar community further south, homes on pilings and residences behind shoreline armor at the Malibu Shores Village could be flooded by large waves today and will become more vulnerable over time. The coastal storm flooding for development on bluffs does not substantially increase with rising tides, but Solromar and the southern County boundary is projected to experience severe bluff erosion. Bluff erosion could also expose cultural resources such as Native American historic villages, shell middens, and cemeteries, as this area has a high likelihood of containing archaeological resources.[27]

Services into the Future

The South Coast provides a host of services that are vulnerable to sea level rise and coastal storms, today and into the future. The continued use of recreation areas, agricultural fields, and private property will depend on the adaptation strategy chosen for the region. Compared with the river flooding projected to occur on agricultural fields south of the Santa Clara River in the Central Coast, the agricultural fields on the

[27] Foster, John M.; RPA, President, Greenwood and Associates; personal communication on December 18, 2018. Also "Archaeological Sensitivity", Ventura County GIS Layer, Source: N. Nelson Leonar, III, Chief Archaeologist, Archaeological Survey, University of California, Los Angeles, July 14, 1973.

South Coast will be exposed to more tidal flooding. Thus, consideration of the effects of higher salinity levels on crop production will be needed.[28] Currently, blueberries, row crops, and sod are planted. If the green-waste processing facility near Ormond Beach is more frequently flooded over time, local waste collection agencies that rely on the facility may be required to haul the waste greater distances to other sites.

Continued services to the residential areas of the South Coast will largely depend on the maintenance of PCH, as water supply lines and power lines run along portions of PCH. PCH also provides a route for emergency services and evacuation of the area. While no wastewater lines run under PCH, septic system maintenance companies use the highway to access the septic tanks that service the residences in Solromar. PCH can be protected by reinforcing the existing seawalls or it can be designed to accommodate some flooding by increasing drainage capacity at key points. Eventually the highway may need to be elevated or relocated inland and these would be the costliest options.

While the continued services will depend on the methods used by Caltrans to maintain PCH, the residential structures oceanside of PCH will be increasingly exposed to coastal storms and rising tides. As noted above, most of the homes at Solromar are either elevated on pilings (Photo 3-5) or protected behind armor (or both). Continued use of these properties will depend on how homeowners choose to adapt for the future. Options include reinforcing the foundations on pilings, increased armor heights, and increased sediment supply to the beaches in front of the development.

As mentioned above, the South Coast has over 100 oceanfront campsites in Point Mugu State Park. The pocket beaches and coves along PCH also offer recreation points for day visitors. While the trails in the Santa Monica mountains have lower risk of coastal hazard exposure and will continue to provide coastal recreation into the future, adaptation strategies for the vulnerable campsites should be considered. The campsites that get flooded during storms today are expected to be closed more frequently with sea level rise. In the long-term, it is likely that these campgrounds will need to be moved inland of PCH. In the short-term, a sediment plan, increased drainage, and elevating key infrastructure could provide some resilience and allow continued use of these low-cost visitor serving accommodations.

[28] New South Wales Department of Primary Industries; "Salinity Tolerance in Irrigated Crops"; December 2016; available at: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/523643/Salinity-tolerance-in-irrigated-crops.pdf

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3. ADAPTATION PLANNING

The complex and evolving nature of sea level rise adaptation demands iterative and implementable solutions that are flexible, with short- and long-term approaches, and a range of small and large adjustments in natural or human systems. These solutions typically involve a wide range of policy, programmatic, and project-level measures, ideally undertaken in advance of the impacts, working with multiple departments and adjacent jurisdictions. When solutions are implemented, County leaders must choose the level of risk they are willing to tolerate. Inaction may result in more costly damages and emergency repairs. Failure to take forward-thinking approaches toward adaptation will result in increased clean-up and maintenance costs. On the other hand, advanced planning to proactively improve resilience could reduce the risk through phased infrastructure equipment upgrades, improved construction design, planned relocation, and new monitoring programs.

Science provides estimates for when the sea level rise impacts will occur. The Vulnerability Assessment provided an understanding of the physical processes and resources in the unincorporated area that will be exposed to sea level rise. It also identified thresholds after which impacts increase from mild inconveniences to more severe damages. This section of the Adaptation Strategies Report identifies a toolbox of potential adaptation measures. Use of the tools will require identification of thresholds for vulnerability and the application of observable triggers for implementation that account for appropriate lead times and weave a diversity of adaptation tools into a cohesive plan. A flexible approach to “adaptation pathway planning” that combines multiple strategies with triggers and thresholds is illustrated in five hypothetical case studies that are presented in Section 3.2 and evaluated in the Appendix B economic analysis.

In undertaking adaptation strategy development, focus will be needed on policies and development standards that could be included in the Local Coastal Program. Some strategies could also become programs in cooperation with other departments and agencies. The approach for the County of Ventura’s first sea level adaptation effort has been to gather information about potentially useful adaptation strategies through consultant recommendations, literature review, and meetings with other departments and agencies. After gathering input regarding potential adaptation strategies, LCP amendments will be prepared to address sea level rise.

This initial effort acknowledges that this is a first step. Future adaptation efforts in the County must address the balance between protecting coastal resources, preserving coastal access and natural resources and protecting the existing built neighborhoods and infrastructure that are vulnerable to sea level rise.

Impacts

While any sea level rise adaptation measure will generate impacts, the extent of those impacts will vary. For instance, the harmful effects of coastal armoring on beaches has been thoroughly described by the Coastal Commission. On the other hand, restoring sand dunes to buffer storm impacts may result in only minimal impacts to views of the ocean. The impacts stemming from adaptation measures that are policies and regulations will be evaluated during the LCP amendment process. The impacts from adaptation projects will be evaluated for consistency with the California Environmental Quality Act before they are authorized. For now, the impacts from each adaptation measure are qualitatively discussed in this section.

In considering impacts, it is important to ensure that adaptation strategies are socially equitable and do not benefit one population to the detriment of another or reinforce existing environmental and societal inequities. This approach is consistent with the recent 2018 update to the State of California Sea-Level Rise Guidance and the Coastal Commission Sea Level Rise Policy Guidance. Given the importance and complexity of sea level rise and coastal planning to the residents of Ventura County, a community engagement effort that includes outreach and education as well as community feedback opportunities will be critical. Some social adaptation recommendations from Appendix C of the Vulnerability Assessment which focused on vulnerable populations likely to be impacted by sea level rise are provided below:

- Develop a sea level rise retreat strategy with habitat restoration and public access at Ormond Beach that could reduce current environmental pollution and increase coastal recreational opportunities for the most vulnerable populations in the unincorporated County coastal zone.
- Initiate an "adopt a neighbor" campaign to help senior residents or residents with disabilities that are most vulnerable during a coastal emergency evacuation, particularly in the communities of the North and South Coasts.
- Provide educational materials with information on renter's insurance to residents of the coastal zone. These should also be made available in Spanish, especially for Central Coast populations.
- Incorporate a coordinated population vulnerability analysis for all coastal jurisdictions in the county, possibly in the Ventura County Multi-Hazard Mitigation Plan.

Cumulative Effects

Cumulative effects result in changes to the environment caused by combined impacts of past, present and future projects. Similar to the impacts described above, cumulative effects resulting from adaptation strategies will be evaluated at the programmatic or project level and are briefly described for each measure in this section.

Adaptation planning requires the consideration of cumulative effects on land uses, the interconnected ecological, social, and economic systems, and how these systems change during the past, present, and future, particularly with sea level rise. Unfortunately, maladaptation is a common occurrence that causes cumulative effects on coastal systems. In contrast to adaptation, maladaptation is a result of adjustments in natural or human systems that are or become more harmful than helpful. Maladaptation occurs when different adaptation measures that are used to alleviate a vulnerability in one sector increase the vulnerabilities in another sector. According to the Intergovernmental Panel on Climate Change, maladaptation inadvertently increases the vulnerability to sea level rise hazards and can be a result of poorly planned adaptation actions or decisions that place greater emphasis on short-term outcomes than longer-term threats.

One adaptation measure may reduce an identified hazard in the short term but lead to unintended secondary effects in the long-term. An example of maladaptation is the levee system for the City of New Orleans. While the levees provided for short-term adaptation and allowed communities to remain in areas that lie below sea level, they increased the long-term vulnerability to flooding— both by providing a false sense of security and by being under-engineered or insufficiently maintained to account for the impact of large storm events.

One of the most significant concerns with maladaptation is that it reduces incentives to adapt for the future by establishing a false sense of security in the near term that places the community, its assets, and residents at risk. When efforts that were intended to "protect" communities and resources eventually fail, development that was allowed in hazardous areas becomes more costly and time consuming to maintain, and often perpetuates future disasters. Redevelopment and repairs can misplace financial resources that could otherwise be used to promote coastal resiliency. Previously unaffected areas can also become more prone to sea level rise-induced hazards if the system that is being altered is not sufficiently understood. For instance, if new shoreline development is designed based on the assumption that beach widths will not decrease, yet the rate of sediment deposition on the beaches is declining, the new development will be increasingly difficult to maintain as the beach erodes.

Key characteristics of maladaptation include:

- Creates a more rigid system with a false sense of security and severe consequences;
- Increases greenhouse gas emissions; and
- Reduces incentives to adapt.

When local communities are awarded federal funding (e.g. FEMA) to rebuild after natural disasters such as floods or fires, the requirement to rebuild according to the current policies and zoning code standards could be considered maladaptation, if adaptation is not already integrated into the policies and standards. Thus, tying community adaptation measures to the FEMA Local Hazard Mitigation Plan can shift federal funding from efforts that support maladaptation to supporting efforts that enhance long-term adaptive capacity. Similarly, maintenance of highly-exposed infrastructure, such as some areas of Pacific Coast Highway along the County's South Coast, could be considered maladaptation as repairs and maintenance activities preserve the facility's high exposure to hazards.

Avoiding maladaptation is critical to a successful sea level rise resiliency strategy. To do so, the County must first be able to make informed decisions based on an accurate Vulnerability Assessment and determine its own level of tolerance of risks. Flexibility and a precautionary approach are critical to avoiding maladaptation in the adaptation planning process.

When identifying appropriate adaptation responses, the County should use the following principles to reduce the risk of maladaptation:[29]

1. The strategy should support the protective role of ecosystems and sustaining their physical processes.
2. The strategy should avoid disproportionately burdening the most vulnerable citizens.
3. The strategy should avoid high-costs, unless holistic economic work (including ecosystem services, infrastructure upgrades, and damages) demonstrates a strong net benefit over time.
4. The strategy should incentivize adaptation (e.g., reward early actors).
5. The strategy should increase flexibility and not lock the community into a single long-term solution.
6. The strategy should reduce decision-making time horizons to better incorporate the evolving science of sea level rise.
7. The strategy should not increase long-term greenhouse gas emissions.
8. The strategy should account for long-term maintenance costs over time, and those costs should be lower than they would be without use of the strategy.

[29] Barnett, J. & O'Neill; Maladaptation, *Global Climate Change*; 2010

Long-Term Adaptive Capacity

Given the wide range of sea level rise impacts that are predicted, the County will need to plan for adaptation over the long-term. Each adaptation strategy has long-term adaptive capacity that is based on the high ability of the strategy to evolve naturally with the physical processes, or a low capacity that requires substantial engineering and construction to enhance. Adaptation measures identified as most appropriate today will need to be revisited and revised over time, particularly as impacts increase. The adaptation pathway will require difficult decisions to reduce risk and improve long-term community resilience.

As not all issues can or should be addressed at once, it is important that the responses to risks be prioritized and phased to maximize the use of the County's resources while avoiding a costly emergency response. Specific early investments can help avoid costly maintenance or repairs in the future. For example, an economic analysis conducted for Imperial Beach shows that by purchasing at-risk coastal properties and leasing them back to owners, the City could realize its return on investment within a normal 30-year mortgage period. If the City owned properties would be damaged before then, the City would lose some money but still retain the right to remove structures and maintain beach recreation and tourism. If damages to those structures don't occur, then the City could realize a gain and put the positive returns into further adaptation measures.

Another challenge is that most adaptation strategies take substantial time to implement. For example, the Surfer's Point project in the City of Ventura took 16 years to conceive, design, permit, finance and complete in 2013. Identifying triggers that catalyze the next phase of adaptation planning that consider the lead time for planning, permitting and construction is imperative.

An overarching adaptation plan is likely to use a variety of approaches over time. Hybrid approaches will likely cycle from protect, to accommodate, and then possibly to retreat, as the sea level rise impacts exceed individual strategies' ability to accommodate sea level rise and reduce vulnerabilities from higher, more frequent exposure (although this cycle will vary from location to location depending on site-specific vulnerabilities). For example, maintaining the existing armoring on the North Coast may be combined with some sediment retention and beach nourishment to increase coastal access, widen beaches, and provide more natural buffers for storm protection. Ultimately, the adaptation strategies selected should be included in a plan that will increase long-term adaptive capacity, which means resiliency to 5 or more feet of sea level rise.

Long-term adaptation planning comes with challenges. A single jurisdiction like the County of Ventura cannot adapt to sea level rise on its own. A successful process requires regional dialogue and partnerships to identify, fund, and implement solutions. Challenges include acquiring the necessary funding for adaptation strategies, communicating the need for adaptation to elected officials and local departments, and gaining commitment and support from federal, State, and local government agencies to address the realities of local adaptation. Lack of resources and limited coordination between local, state, and federal agencies can make it difficult for local governments to make significant gains in adaptation.

Finally, important thresholds that will trigger planning processes and implementation efforts need to be identified. Policies and programs in the LCP can help identify specific thresholds that trigger specific actions. Factors to consider when prioritizing projects include: public health and safety, available funding sources, legal mandates, planning consistency, capacity and level of service, cost-benefit relationship, environmental impacts, and public support. Risks that present the most serious consequences and are projected to occur first should raise a project's level of priority.

Critical to the successful implementation of an adaptation strategy is communicating the issues and proposed response strategies to the community. Studies repeatedly show that knowledgeable and prepared communities with educated decision-makers that understand how to respond to extreme events will be far more resilient. An informed community is also more likely to make decisions that anticipate and plan for the projected changes. To advance understanding of long-term adaptive capacity, this section provides a qualitative summary for each measure.

Protect, Accommodate, and Retreat: The Approaches to Coastal Adaptation

Coastal adaptation generally falls into three main categories: protect, accommodate, or retreat. There are also the options of doing nothing or hybridizing the strategies over time. A hybrid approach to adaptation allows a flexible pathway for balancing economic, environmental, and safety goals over time.

The Protection Approach

Protection strategies employ some sort of engineered structure or other measure to defend development (or other resources) in its current location without changes to the development itself. Protection strategies can be divided into "gray" and "green" defensive measures, and then further divided into "hard" and "soft" measures. A "gray", "hard" approach is usually an engineered structure that can be positioned either alongshore (such as a seawall, revetment, or offshore breakwater) or cross-shore (such as a groin or harbor jetty). Cross-shore structures tend to trap sand and widen the beach up-coast of the structure. A "soft" protection approach may be to nourish beaches, while a "green", "soft" approach may be to restore sand dunes.

The California Coastal Act clearly allows protective devices for coastal-dependent uses, existing structures, or public beaches in danger from erosion when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. It also directs that new development be sited and designed to not require future protection that may alter a natural shoreline. It is important to note that most protective devices are costly to construct, require steadily increasing maintenance costs, and have impacts on recreation, habitat, and natural defenses such as beaches and wetlands. Many of these consequences are forms of maladaptation, especially if the protective device was intended to be a long-term solution.

The Accommodation Approach

Accommodation strategies employ methods that modify existing development or design new development to decrease hazard risks and therefore increase resilience to the impacts of sea level rise. On an individual project scale, these accommodation strategies include actions such as elevating structures, performing retrofits, using materials to increase the strength of development to handle additional wave impacts, building structures that can easily be moved and relocated, or using additional setback distances to account for acceleration of erosion. On a community-scale, accommodation strategies requiring the above-mentioned types of actions could be integrated into the land use plans, zoning ordinances, and strategic planning documents for partner agencies.

The Retreat Approach

Retreat strategies relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. This approach is not an evacuation, but rather a strategic means to remove the most vulnerable development and infrastructure from harm's way while maintaining coastal resources and access for future generations. Such strategies are commonly considered as longer-term options. Consistent monitoring and thresholds associated with certain sea level rise amounts can be used to transition from protect and accommodate strategies to retreat. Once a given sea level rise amount is reached, the planning or implementation of a selected retreat strategy would be triggered. Although retreat is unlikely to be a necessary management tool in the near term, the establishment of necessary programs and implementation processes that would facilitate these strategies will likely take years to develop and finalize, thus emphasizing the need for proactive long-term planning. Examples of retreat strategies include acquisition and buy-out programs, transfer of development rights programs, repetitive loss programs and hazard buffers or setbacks.

The Wait and See Approach

Choosing to "wait and see" or following a policy of "non-intervention" may be considered a form of adaptation. This "wait and see" approach tends to result in substantial damages and costly emergency repairs that could be avoided through proactive planning to ensure conservation of coastal resources and protection of development. Also, there are overarching concerns that the lengthy process to plan, permit, and enact resiliency measures will be outpaced by the exponential increases in sea level rise impacts. In other words, taking a wait and see approach today may hinder adaptation efforts in the future, at a time when they are the most needed. As natural disasters have occurred around the country in recent years, many communities rebuild or re-site development at a huge expense. Waiting for a disaster to remove development from high-risk areas is not a safe nor cost-efficient method, and it does not provide a pathway for comprehensive resiliency planning that addresses the needs of the community.

The Hybrid Approach

For purposes of implementing the California Coastal Act, no single category or even specific strategy should be considered the "best" option as a rule. Different types of strategies will be appropriate in different locations and for different hazard management and resource protection goals. The effectiveness of different adaptation strategies will vary across both spatial and temporal scales. In many cases, a hybrid approach that uses strategies from multiple categories will be necessary, and the suite of strategies chosen may need to change over time. Nonetheless, it is useful to think about the general categories of adaptation strategies to help frame the discussion around adaptation and to consider the land use planning and regulatory options that are available to the County.

3.1 Adaptation Strategies for County of Ventura

The Vulnerability Assessment identified areas with existing hazards and areas that will be affected by sea level rise. After meetings to review the results of the Vulnerability Assessment with other agencies, departments, and the Natural Resources Working Group, the following sea level rise adaptation strategies were identified as potential solutions that could be used to address existing hazards in a manner that is generally compatible with goals, projects, and programs of the County and partner agencies. Additional strategies were developed by the Natural Resources Working Group and are summarized in Appendix A.

The adaptation strategies range in scale from project to programmatic approaches, and in most instances additional planning and updates will be needed for implementation. Some strategies may fall in the permitting category of repair and maintenance, and others would require a discretionary permit, such as the construction of sediment retention devices. Most “pilot projects” would require funding for feasibility studies, future permits, construction, and later for ongoing maintenance and monitoring. Any given strategy alone is unlikely to suffice through the predicted changes, but rather a phasing plan with a mix of strategies will be required, often through the identification of triggers for when one strategy is supplemented by or transitions to another.

County-Wide Adaptation Strategies

Although existing land uses vary considerably on the North, Central, and South Coasts, the following strategies could be applied throughout the coastal zone. These strategies are not listed in any order nor are they prioritized. Following this section, specific strategies are also discussed for the North, Central, and South Coast areas of the unincorporated area.

Coastal Hazard Overlay Zone (Strategy CW-1)

Overlays are a land use planning tool that prescribe regulations for a specified geographical area. Given the projected extent of coastal hazards and sea level rise, a coastal hazard overlay could provide a method to bundle coastal hazard and sea level rise land use regulations into one reference source that is easy to find and understand. For example, a coastal flood hazard overlay could apply to both the coastal and non-coastal zoned areas, since vulnerabilities are predicted to extend inland of the coastal zone boundary.

While there are many types of regulations that could be included under an overlay, the following could be applied specifically to address coastal hazards:

- Technical Reports: Since the prevalent sea level rise models such as Coastal Resilience and CoSMoS are not intended for project-level analysis, more precise studies are needed to ensure new development is sited and designed for sea level rise resiliency. Coastal hazard reports typically include a summary of current and historical coastal hazards, projected future hazards, and resiliency measures that will be included in the proposed development to address the identified hazards. Wave uprush, erosion and scour rates, and the effects that the development would have on beach sediment, bluffs, and dunes located on and downcoast from the site are examples of technical studies that could be included in a Coastal Hazards Report. A beach erosion or bluff erosion mitigation plan may also be included.
- Real Estate Disclosures: A notice can be recorded on the property title for access by current and future property owners that provides a reference to the coastal hazards report that is maintained on file at the Planning Division, acknowledges that current and future coastal hazards are projected to become more severe, discloses the conditions of approval for the development, and acknowledges the potential for the public trust boundary to move inland, encompassing part or all of the development.
- Assumption of Risk and Indemnification: Applicants for new development may be required to indemnify the County for personal property damage and acknowledge that public funds may not be available to repair roadways, utilities, and other facilities, when damages result from coastal hazards. The County could also abdicate responsibility to provide access to the property in the future. Also, if sewage disposal or water supply systems become inoperable, occupation of the structure would be prohibited.

- Conditions of Approval: Resiliency measures identified in the technical hazards report, real estate disclosures, and indemnification may be required through conditions of approval for new development. In recent years the Coastal Commission has conditioned new shoreline development to forgo the use of coastal armor. (Also see Strategy CW-9 below.)
- Special Assessment Districts: Overlays can be used to identify underlying properties that will be assessed an additional tax that would be used to fund specific adaptation improvements to the area. Stormwater infrastructure improvements, beach nourishment, and protective sand berms have been funded by special assessment districts. A majority vote by the affected property owners is required to form a special assessment district.
- Development Standards: Standards for the scale, intensity, and location of development can be prescribed through an overlay zone. Usually the standards are more restrictive than the underlying zoning would allow, but they can also be more permissive than underlying zoning if used to reduce requests for variances and allow for additional height if buildings need to be elevated to accommodate sea level rise. Development standards could also be used to promote uniform design of coastal armoring (also see North Coast, Strategy NC-1).

Impacts: In some areas the coastal hazards extend inland beyond the coastal zone, and therefore the County's General Plan, Local Coastal Program, and Non-Coastal Zoning Ordinance could be required to be updated to identify a defined coastal hazard overlay. Also, as sea level rise projections and science evolve, the maps showing the areas that will be exposed to sea level rise are likely to change over time. Evolving science showing the areas that may be impacted could require progressive updates to the overlay zone, which could be costly to process. As improved science and modeling refines the hazard projections, then an update of the hazard map could expand or contract the hazard overlay. The coastal hazard overlay should generally cover a cover a larger area than the FEMA flood insurance rate maps, which do not consider sea level rise or coastal erosion.

Cumulative effects: The regulatory capacity of the overlay depends on quantity and scale of the regulations that are included. Each regulation would generally be consistent with an adaptation strategy and evaluated for cumulative impacts during the adoption of the overlay.

Long-term adaptive capacity: Moderate. An overlay zone provides a conduit to implement targeted standards and land use regulations. Many of the adaptation strategies listed below could be implemented using a coastal hazard overlay. Approximately one to two years would be required to develop and amend the LCP to implement the overlay. Once the LCP is amended and the overlay is effective, any strategies included under the overlay need to be operative by that time.

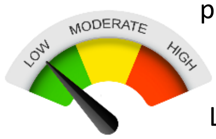
Real Estate Disclosures (Strategy CW-2)

Real estate disclosures provide notice during real estate transactions when a property is located within a hazardous coastal area. The simplest disclosures include a reference on the property title that the development is located in a hazardous coastal area. Some also include a reference to the site-specific coastal hazards report, if such a report was required to obtain authorization to develop the property. More robust disclosures include provisions that require the buyer to assume risks of injury and damage and require the buyer to indemnify government agencies from resulting damages that may occur due to coastal hazards.

Impacts: A disclosure per se is unlikely to impact real estate transactions because most people understand that beachfront properties are inherently affected by coastal processes and forces. Whether a disclosure could decrease real estate values is a subject of ongoing research. One recent study concluded that it depends on whether the home buyers believe that the effects of climate change are real. It found that homes projected to be affected by sea level rise in neighborhoods where the residents have a high tendency to believe in climate change tend to sell for less than comparable homes in neighborhoods where there is less belief in climate change.[30]

Cumulative effects: While disclosures provide information and notifications, they are not intended to dissuade property transactions that are in hazardous areas, but rather inform property owners that their holdings are considered vulnerable to sea level rise exposure and that they would be living in an increased hazard zone.

Long-term adaptive capacity: Low. Disclosures provide notice of sea level rise hazards and educate the



property owner on what those likely changes may be, including an acceptance of risk that potentially reduces the local government's liabilities, but such notices do little to implement a physical action to minimize sea level rise impacts. Consistent with most LCP amendments that are moderate in scope, institutionalizing a process for disclosures would be likely to require one to two years to amend the LCP, develop the boilerplate language, and implement the procedure with the County Recorder and Assessor.

Elevate New Development (Strategy CW-3)

This accommodation strategy addresses sea level rise hazards through raising the base elevation at which the building is constructed. New development could include an increased base flood elevation following FEMA's new revised flood insurance rate maps (FIRM)s with an additional freeboard elevation to accommodate anticipated levels of sea level rise for the expected life of the structure, using whichever height is greater. Including sea level rise in the base elevation of building design would be necessary for adaptation because FEMA maps are based on historical flooding and do not include future sea level rise or coastal erosion. The sea level rise amount used for building design 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 [31](e.g., 75 years for the life of a residential structure). Development standards would likely need to be revised to accommodate the different building design.

Impacts: Elevated structures may appear to be out-of-scale with neighboring properties, especially if adjacent lands have smaller, older residences. The shade from taller development may be considered a significant environmental impact that is difficult to mitigate. Construction costs would increase compared to when the building foundations are set at grade.

Cumulative effects: Elevated structures may cause impacts to visual resources from inland locations, require changes to development standards, and result in the alteration of neighborhood character. In addition, elevated structures may be able to stay in place longer, well past the time at which the sandy

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[30] Baldauf, Markus and Garlappi, Lorenzo and Yannelis, Constantine; "Does Climate Change Affect Real Estate Prices? Only If You Believe in it"; August 2019; available at SSRN: https://ssrn.com/abstract=3240200.

[31] Presently, the best available science is identified in the OPC 2018 Sea Level Rise Guidance.

beach is lost, leading to significant impacts on public access and recreation, and development that may encroach on public trust lands.

Long-term adaptive capacity: Moderate. The elevation strategy requires significant changes, costs, and engineering. However, when land is redeveloped, the structure's foundation may be required to be elevated, especially if setbacks or alternative sites for the development are insufficient to minimize the sea level rise risks. After the appropriate LCP amendments are prepared, this strategy can be immediately used to design new development to accommodate the amount of sea level rise that is projected to occur during its anticipated life.

Interjurisdictional Conservation Planning for Vulnerable Focal Species (Strategy CW-4)

The Vulnerability Assessment report indicates that several federal or state endangered/threatened species and their habitats may be adversely affected by sea level rise. The Natural Resources Working Group identified the need for a countywide comprehensive assessment of all habitats (regardless of jurisdiction) that support federally/state listed species vulnerable to sea level rise (focal species). While the Vulnerability Assessment demonstrated which habitats and focal species in the unincorporated County may be exposed to the effects of sea level rise, an interjurisdictional countywide assessment would be useful for assessing the loss or degradation of all the habitats used by or suitable for threatened or endangered species. Habitats depend on physical processes and landscape connectivity to evolve. Development in adjacent jurisdictions may reduce the ability of habitats to transgress or receive sediment, hindering their evolution. An interjurisdictional focal species assessment would leverage limited resources and help prioritize needed adaptation measures for focal species. Using population numbers, species fitness, existing habitat quality, adjacent upland habitat connectivity and other factors, habitats could be prioritized to identify areas critical to maintain or replace as sea levels rise. This would allow local biologists to identify which adaptive management approach may be needed to minimize sea level rise impacts on local species populations. In addition, these planning efforts may also include several strategies identified by the Natural Resources Working Group for specific focal species or habitats that are summarized in Appendix A.

Impacts: Indirect benefits from protecting focal species habitat would likely include ecosystem services such as improved water quality, increased flood protection, and recreation opportunities. Some of those services, such as flood protection, require collaboration with other jurisdictions to be effective against rising seas (e.g., flooding along the Santa Clara River). These interjurisdictional projects are usually very time consuming and difficult to implement due to the varied interests involved. Therefore, differences in adaptation planning from different localities may depend on the political climate and the priorities of each jurisdiction. This could result in wide variation in the extent to which the jurisdiction is willing to implement the plan. For example, when public lands are occupied by federally- and state-protected species, as well as managed for multiple uses (e.g., recreation), the governing land management agencies are more likely to require additional planning, permitting, management, and enforcement resources than those lands that are unoccupied by these protected species. However, these additional costs may also be negligible because the species are currently occupying those lands and the land management agency is already implementing the requirements.

Cumulative effects: A regional adaptation planning effort needs to be conducted to provide a more accurate representation of the sea level rise threats to imperiled species and all suitable habitats in the county. Restoration in one jurisdiction could be used to offset infrastructure protection or development in a regional context. It also allows for a more comprehensive approach to focal species management and targeting of limited resources and planning tools to areas where they will be most beneficial for the conservation of the species over time. Such an effort could be spearheaded by a federal or State agency with jurisdiction in Ventura County.

Long-term adaptive capacity: Moderate – High. Interjurisdictional advanced planning for vulnerable focal species adaptation is moderate to high. This is because this region-wide strategy allows for a more holistic approach to the management of listed species based on the effects of sea level rise. A region-wide plan could also create a broader context for funding that would allow multiple jurisdictions to conduct restoration projects. Once developed and adopted, the County would not have any authority over whether other jurisdictions implement the recommended adaptation strategies. Such planning projects often require collaboration and coordination from multiple stakeholders which increases the difficulty and time required to implement them. The effort for interjurisdictional focal species planning could begin as soon as funding and staffing resources are allocated, however, the preparation and adoption of LCP amendments for habitat planning among multiple jurisdictions would be difficult to achieve. A streamlined approach could entail having a wildlife management agency or non-profit organization lead the effort and prescribe recommendations and best management practices for each jurisdiction. Once a multi-jurisdictional plan is developed, years of monitoring would likely be required to verify whether the measures are effective. Nonetheless, this strategy may be necessary for long-term species conservation across the County.

Adaptive Management Planning for Sensitive Habitats (Strategy CW-5)

The development of adaptation strategies for complex environmental systems such as sand dunes, wetlands, streams, rivers and estuaries will require the analysis of site-specific data to understand how these ecosystems will be affected by changes in sea levels. Often, ecosystems with water resources are under the jurisdiction and management of several entities with numerous stakeholders. This would require a more involved planning process for developing viable adaptation strategies.

The Natural Resources Working Group recommended that all entities and stakeholders responsible for the management of the County's estuaries (Rincon Creek, Ventura and Santa Clara Rivers, and Sycamore Canyon) and connected habitats, develop site specific management plans that select the appropriate adaptation and monitoring strategies (protect, accommodate, retreat) and actions (e.g., construction of marsh sill/horizontal levee to protect adjacent land uses, restoration of niche habitat for rare species, development standards, etc.), with specific triggers for policies or implementation of management activities associated with definitive changes from sea level rise. The selection of appropriate triggers should be based on consistent monitoring of key variables such as estuary water levels, stream flow, beach width, and estuary breaching frequency. Regional efforts to standardize and centralize the data collection and sharing would facilitate this adaptation measure.

Existing management practices such as beach grooming, vector control, invasive species prevention, and other maintenance/management activities should be evaluated as to the long-term benefit of species. Adaptation strategies developed could also utilize additional studies and data developed by The Nature Conservancy and California State Coastal Conservancy's Coastal Habitat Assessment Tool. Over the long-term, species planning efforts could also identity vulnerable populations for translocation due to future isolation, habitat fragmentation, and loss.

Cumulative effects: Appendix A provides limited recommendations for adaptation strategies associated with habitats such as sand dunes, estuaries, and lagoons. More coordination with stakeholders and additional resources would be required to develop viable approaches to sea level rise resilience. These natural ecosystems arguably provide the most valuable ecosystem services to the County (such as flood control and water supply filtration, etc.). These habitats are projected to be imperiled throughout Southern California due to development and the long-term effects of sea level rise and their cumulative loss could be high if nothing is done.

Impacts: This planning effort would require dedicated staff time and coordination with agencies and adjacent municipalities to be developed and implemented. The issues are complex when the habitat covers multiple properties or straddles jurisdictional boundaries, which is the case for most habitat areas evaluated in the Vulnerability Assessment.

Long-term adaptive capacity: Moderate – High. Sensitive habitat adaptation planning could provide a context for employing green solutions and conserving areas that are refugia for protected species only found in Ventura County. Similar to the interjurisdictional conservation planning discussed above, this measure is likely to be most effectively conducted through the leadership of a wildlife management agency or a non-profit organization that can prescribe recommendations and best management practices for each jurisdiction. These agencies are often already monitoring the habitats and gathering data. Since the planning effort would provide a conduit for implementation of multiple strategies and methods, as shown in Appendix A, the individual strategies would still require evaluation of the cumulative effects, potential impacts, and long-term adaptive capacity.

Sediment Management (Strategy CW-6)

Sediment such as sand and rock cobble are an increasingly valuable commodity for coastal management. Sediment is also nature's adaptation resource that has maintained wetlands and beaches throughout time. Utilization of these natural materials could increase overall coastal resilience by increasing elevations and buffering the coast from storms. Sediment management generally ensures there is habitat for beach-dwelling species such as the California grunion or Western snowy plover and it promotes public beach access. Coastal residents have expressed some support for using this natural buffer in conjunction with shoreline armor.

BEACON is a California Joint Powers Agency established in 1986 to address coastal erosion, beach nourishment, and ocean water quality along shorelines from Point Conception to Point Mugu. The member agencies of BEACON include the Counties of Santa Barbara and Ventura as well as the coastal cities of Santa Barbara, Goleta, Carpinteria, Ventura, Oxnard and Port Hueneme. The BEACON Board adopted a Coastal Regional Sediment Management Plan in 2009 that provides a framework for how regional sand management could be employed on the North and Central Coasts, but the plan did not include sea level rise in its evaluation. The Surfer's Point Managed Shoreline Retreat project in the City of Ventura was a substantial project that was included in the plan. Presently, BEACON's Coastal Regional Sediment Management Plan is only applicable to areas within the reach of the Santa Barbara Littoral Cell, and therefore the South Coast of the County is not included.

The different possibilities identified for sediment management in Ventura County include: (1) opportunistic sediment placement that could include dredge sediment reutilization/nourishment; (2) sand retention through non-permanent perpendicular shoreline structures; (3) re-establishment of native coastal dune habitats on the Central Coast; and (4) sediment bypassing around Point Mugu to nourish the Zuma Littoral cell on the South Coast. Of the above strategies, only the third one, dune restoration on the Central Coast, is a project in which the County could choose to be the lead agency. The other three strategies all involve activities below the mean high tide line, which require State and federal authorization. The opportunistic sediment placement option is described below, since it could be used county-wide. The others are discussed in subsequent sub-area discussion sections, because those are the locations that could benefit the most from that particular sediment management strategy.

Impacts: Sediment management can have multiple impacts depending on the means to transport the sediment, the size of the sediment and its compatibility with existing habitats, and the frequency of placement. For example, sand-dwelling, burrowing animals are negatively impacted when large amounts of sand are deposited over a short period, and some nearshore habitats are adversely affected by continuous high levels of turbidity. However, the Ventura coast is well adapted to deposition of large sediment pulses from flood events. Sand is beneficial in that it provides a unique habitat and ecosystem services by filtering and percolating water. It also accommodates recreational activities. Sand is naturally transported along the coast, and due to harbor and flood control practices, there are multiple ways to harvest sediment resources and maximize the habitat and recreational benefits. However, sand is difficult to manage, and may be blown on shore, into storm drains, and throughout developed areas. Sand could be deposited on a beach, through a costly process, only to result in it being transported by longshore currents out to sea or onto other beaches.

Cumulative effects: Depending on the management activity, ongoing monitoring and maintenance could be required. For example, increasing the amount of native sand dunes at Hollywood and Silverstrand Beaches could increase resilience to storm event impacts, improve recreation and habitat value, and lower beach grooming costs. The presence of wider sandy beaches and more dune habitat would be beneficial to vulnerable focal species studied in the Vulnerability Assessment. Sand management provides a good strategy for the short-to mid-term in all parts of the County, but when sea levels rise by about 5 feet, the sediment is increasingly likely to be tidally inundated and may need to be combined with other strategies, particularly on the North and South Coast.

Long-term adaptive capacity: Moderate – High. Would need to be combined with other strategies such as design of development for accommodation of coastal storm flooding to improve long-term resiliency. The next sections include summaries of more specific sediment management strategies: (1) opportunistic sediment placement that could include construction of sand berms, as summarized in Strategy CC-4, or dredge sediment reutilization/nourishment, as summarized in Strategy CW-7, and Strategy CC-2; (2) sand retention through non-permanent perpendicular shoreline structures, as summarized in Strategy NC-2; (3) re-establishment of native coastal dune habitats on the Central Coast, as summarized in Strategy CC-1; and (4) sediment bypassing around Point Mugu to nourish the Zuma Littoral cell on the South Coast, as summarized in Strategy SC-5.

Opportunistic Sediment Placement (Strategy CW-7)

Sediment transport to the coast has been altered as a result of dam and debris basin construction, urban development, and coastal armoring. The placement of sediment, such as sand and cobble, on shorelines is a method that mimics natural processes and can be used to offset erosion or protect development. Through methods that reconnect disrupted sediment transport pathways to the coast, sediment placement could mitigate the effects of erosion, improve habitats, and buffer storm impacts.

A goal would be to reconnect and retain sand in the same littoral cell that would otherwise naturally be delivered through erosion of bluffs, outflow of rivers, and through longshore currents, but has not been delivered due to obstacles and drought. Generally, drought, dams and basins along the Santa Maria, Santa Ynez, Ventura, and Santa Clara rivers have led to an approximate 40% reduction of natural sand supply in the Santa Barbara Littoral Cell.[32]

The separation of bluffs from the beaches on the North and South coasts due to roads, coastal armoring, and other improvements such as the rail line (on the North Coast) impedes the natural erosion process that would otherwise supply sand and cobbles to the coast. The sediment from coastal landslides such as the Montecito debris flow is typically hauled to offsite disposal areas rather than following natural pathways to deposition into the coastal zone. Perennial drought and lack of large rain events means that the rivers are washed-out less frequently, resulting in accumulation of sediment in inland debris basins and storm channels. This sediment accumulation could increase potential flood exposure and risk. The County has 55 drainage basins that are accumulating sand and cobble of various qualities and conditions. Opportunistic sediment management would identify potential inland debris basins and storm channels to source sediment, receiver beaches, stockpile and sorting sites, and it would streamline environmental review programmatically to facilitate the placement.

Another option would be to engage with the US Army Corps of Engineers for more opportunistic dredge sediment placement to restore habitats and increase resiliency. Harbors and groins have historically impeded downcoast sediment movement that otherwise occurs through longshore currents. The US Army Corps administers the harbor dredging throughout the county, typically just bypassing sediment.

Some specific examples of sediment placement practices that could restore inland and bluff sediment sources to the sea include the following:

- Identify sources of sediment in watershed debris basins and stockpiling areas that could be provided to landowners, Caltrans, State Parks etc. for deposition on sites with erosion “hotspots” or on areas that have been identified for beach nourishment.
- Identify sorting and stockpiling areas near the coast that could be used to store excess sediment until it can be utilized for placement.
- Develop agreements with the Union Pacific rail line to transport sediment to designated receiver sites.
- Modify the equipment on debris basis to allow more sediment to reach the coast. The removal of the Matilija Dam would be a prime example. Including perforated debris bleeders on detention basin spillways is another example of improvements that allow sediment to bypass basins in order to reach the coast (see Figure 3-1).
- Reduce hazards and the time of closures required to clean up roads due to landslides by allowing Caltrans to deposit sediment from landslides onto the shore. Coastal bluffs could be pretested for sections with sand grains suitable for deposition onto beaches or in the surf zone.[33]

[32] Presentation by Dr. Kiki Patsch; Basics of Coastal Processes Workshop; September 10 to 14, 2018; referenced Willis et al 2002; Runyan and Griggs 2002.
[33] California Department of Water Resources; Sediment Management, number 19 on pg. 35; July 2016.

Figure 3-1 This debris basin includes a perforated "debris bleeder" made from a corrugated metal pipe (circled in red). (Source: VC Watershed Protection District)

Impacts: Sand placement on the beaches could include unintended consequences depending on the frequency and volume of placement as well as the compatibility of the placed sediment with existing grain sizes. Wetlands typically need finer grained sediments which often attach to pollutants and cause turbidity. Episodic placement particularly during energetic wave events would reduce many of these impacts and should be evaluated as part of the plan.

Generally, sand-dwelling, burrowing animals are negatively impacted when large amounts of sand are deposited over long periods of time, but the extent of the impacts largely depends on the quality of the sand, and duration of placement. The grain size and angularity of the sand are key factors that shape the beaches. Large grain sizes and sharp, pointed grains are less supportive of biodiversity. Conversely fine-grained sand may be compacted to the extent that it hardens to a clay-like consistency that is unpleasant for recreational activities. Thus, sediment compatibility is a critical element and potential sources need to be carefully tested for suitability. Overall, opportunistic sediment placement helps maintain beaches and results in fewer long-term impacts than coastal armor.

Cumulative effects: Opportunistic sediment placement would restore some of the sand supply that historically reached the coastal beaches but is currently impounded. Depending on the extent of the practice, it could restore millions of cubic yards of sediment to the shoreline and reduce the rate of beach and wetland loss. However, the amount of sand manually delivered would depend on how many source areas prove to be a suitable match to sediment that naturally occurs on local beaches and the frequency and duration of placement at receiver sites. Ongoing management and maintenance would be needed, but may be factored into reducing the costs of business as usual for managing flood control channels and debris basins, cleaning up after landslides, and mitigating coastal erosion.

Long-term adaptive capacity: Moderate – High. Initially, authorization and planning for sediment deposition on the coast requires an initial investment in sediment compatibility analysis, as permits would be required from the Coastal Commission and the Army Corps of Engineers. Prior to and during the authorization, testing for suitable grain sizes from potential source sites and pollutants would be needed to best match with potential placement or receiver locations. Finally, the transportation routes, storage areas, and access points would need to be carefully planned. The permits would also need to be periodically renewed.

The long-term efficiency of sediment placement and retention would depend on many factors, such as the topography, swell and longshore currents, sediment size, and wind direction. More analysis and likely inter-agency agreements would be needed to estimate the volume and frequency of sediment delivery needed to offset sea level rise impacts to local beaches. However, unless the natural pathways for sediment deposition on beaches are restored, creative solutions will be required to maintain beach widths. Generally, sediment deposition would help to protect against and accommodate the near- to-mid-term sea level rise projections that range up to two or three feet. Most importantly, long-term sediment deposition would provide a near- to-mid-term alternative to traditional shoreline armor. In the long-term, however, more permanent solutions may be required, as higher elevations will need be needed to maintain beaches.

Voluntary Managed Retreat (Strategy CW-8)

In the long-term, beaches, dunes, bluffs, and marshes will need space to migrate inland and upward in elevation or risk permanent loss due to erosion and tidal inundation. According to the Vulnerability Assessment, beaches provide an estimated $156 million annually in revenues to businesses and tax revenues countywide. When existing development such as seawalls, roads, and buildings block the pathways for these habitats to migrate inland, there are few viable alternatives to conserve the shorelines in the high-wave-energy Pacific coastal environment. Managed retreat, a plan for the phased relocation of infrastructure and development, could be used to maintain coastal resources by allowing land to naturally erode and evolve through the geologic physical sediment transport processes that provide space for beaches, dunes, bluffs and marsh. Managed retreat also applies to important vulnerable County infrastructure identified in the vulnerability assessment which could be relocated away from future coastal hazards.

While the Coastal Commission Sea Level Rise Policy Guidance generally suggests that retreat should be considered for all land uses, beaches and other undeveloped areas are typically the areas that are the most feasible to accommodate retreat. Another benefit is that this is possibly the only adaptation strategy that managers could generally “walk away” from and still allow for the continuation of natural coastal processes such as beach erosion and accretion with only minimal management needed. Local and state agencies that manage undeveloped and sparsely developed areas are more likely to elect to use a managed retreat approach to relocate facilities inland and maintain public access, recreation, and aesthetics when compared to private landowners in urbanized areas.

The Vulnerability Assessment identified the following sparsely-developed areas and recreational areas as being potentially suitable for managed retreat:

- Inland Areas of Ormond Beach (Figure 2-11, 2-12): Though primarily located in the City of Oxnard, restoration planning for the Ormond Beach wetlands by the City, the Nature Conservancy, and US Army Corps has included consideration of its historic extent, which would include unincorporated inland areas. If restoration of the historic reaches of the wetlands is pursued, this scale would be conducive to supporting a variety of wetland habitats that may otherwise be constricted by sea level rise.
- Thornhill-Broome Beach Campsite (Photo 2-8, Figure 2-14): This campsite in Point Mugu State Park could be relocated inland of Pacific Coast Highway as seasonal closures increase in frequency. If facilities are relocated into the mouth of La Jolla Canyon, the campsite could potentially be designed in a similar configuration as Sycamore Cove.
- County Line Bluffs (Figure 2-15): The bluffs on the South Coast near the Ventura-Los Angeles County line could be allowed to retreat inland without any impacts to Pacific Coast Highway, although a few structures and outbuildings on State Parks property would be affected.

- County Parks and Rincon Parkway (Photo 3-7): A more progressive and long-term retreat strategy on the North Coast could include shifting Hobson and Faria County Parks, and the Rincon Parkway, inland. But new sites would need to be leased or acquired, such as the agricultural field on Hobson Road. This could allow for expansion of camping and other recreational uses that would otherwise be affected by increasingly frequent closures. Such a strategy would largely depend on long-term plans for Old Coast Highway, which to date has not been associated with any planning efforts that considered retreat or removal.

Impacts: Retreat of some areas would increase the exposure of other areas that currently experience the effects of erosion, such as individual parcels in the middle of an armored stretch of coastline. It could also result in a decrease in property tax revenues. The benefits of retreat include the option to redesign public facilities to enhance public recreation, and expand access to camping venues, day-use facilities, trails and natural habitat that presently provide substantial revenues from visitors.

Cumulative effects: Retreat allows for the continuation of natural processes and ecosystem services; however, when other land uses such as roadways are prohibitively difficult to remove, these other uses function as human-made boundaries for retreat that restrict the continuation of these natural processes. For example, the retreat of sensitive wetlands at Ormond Beach would be restricted by surrounding agricultural lands. Thus, while retreat of a specific area may be beneficial for a certain amount of time, the past, current, and proposed uses on surrounding upland lands are also essential for the long-term adaptive capacity of this strategy.

Long-term adaptive capacity: Moderate – High. Managed retreat allows space for the coastal physical processes to function naturally and relocates uses further away from the vulnerabilities. However, some landowners may opt to not to participate in voluntary retreat and it would be extensively difficult to apply to densely urbanized areas of the coast. This strategy is implicitly being used by State agencies when they decide not to install coastal armor on beaches and parks. Development of a managed retreat plan that involves multiple land owners would likely require five to ten years to prepare a coordinated plan. Funding sources would also need to be identified for private lands. If voluntary retreat can be successfully funded, planned, and implemented, it is one of the few adaptation strategies that would be effective through over 5 feet of sea level rise.

Regulatory Mechanisms to Encourage Retreat (Strategy CW-9)

A reduction in the extent, type, or number of times that a property can be developed is often an unpopular and controversial way to reduce the risk of hazards because it typically reduces development potential and property value. However, it is an effective method to minimize the number of lives and property that may be exposed to dangerous conditions. There are several regulatory methods to scale back the amount of development in hazardous areas and phase retreat. The overall high value of coastal properties makes the fiscal realities behind using these methods challenging, particularly when these properties are insured. In general, there are high initial costs to purchase oceanfront property or easements for each property, and as structures are removed, there would be reductions in property tax revenues. Other, non-market-based options supported by the Coastal Commission are controversial, such as conditions on new development that require waivers restricting coastal armor. Given funding challenges and the lack of legal precedent for some measures, a combination of measures employed at both the local and State level may provide the best chances for success.

The Coastal Commission, Coastal Conservancy, and Ocean Protection Council are State agencies that strongly support the retreat strategy on both private and public property. These agencies have recommended that local jurisdictions use the following regulatory measures to facilitate retreat on private property:

- FEMA Severe Repetitive Loss: Property owners that have submitted multiple flood insurance claims to FEMA can be compensated in exchange for agreeing to a deed restriction that addresses the future demolition or relocation of flood-prone structures. When a structure is demolished or damaged beyond repair, the deed restriction could require the development to be removed or relocated and the property to be used for open space. In the past, landowners in flood-prone inland areas that were approached by the County declined to apply for a repetitive loss grant through FEMA. According to the 2010 Multi-Hazard Mitigation Plan, there were only three severe repetitive loss properties in the County, and only one was located along the coast, at Solromar.
- State or Local Severe Repetitive Loss: Another type of repetitive loss strategy could be developed at the State or local level. For example, there could be cap on the number of permits issued to repair or replace structures on a flood-prone site over a rolling 10-year period. After three flood events, the State or local government could have a right of first refusal to purchase the property at damaged value. This strategy could possibly be combined with the FEMA program to provide just compensation while restricting redevelopment in sea level rise hazard areas.
- Buffers: Geographic boundaries that either restrict potential development or require additional review for development proposals can be applied in the form of buffers that radiate from points or polygons on a map that represent land uses deemed worthy of preservation or conservation. An example of buffers for land use planning are the "redline" channels that are identified by the Watershed Protection District. A permit for development in redline channels requires analysis of the project's effects on the watercourse, and the use of project features and mitigation measures to offset impacts. For sea level rise, similar types of buffers could be used to conserve areas that should be reserved for habitat, or could be unsafe for use when the effects of sea level rise become more pronounced.
- Mitigation/In-Lieu Fee Programs: The objective of a beach sand in-lieu fee program is to compensate the public for the potential loss of recreational use of the public beach due to the installation of a shoreline protective devices such as a revetment that covers a public beach. Fees collected through the program could be based on an estimate of the amount of sand lost from the beach due to armor-induced erosion and the amount of sand located under the footprint of the portion(s) of the structure on the public beach. Funds could be used locally for beach nourishment, access projects such as stairways, or the purchase of conservation easements.
- Purchase with Lease Back: The premise of this strategy is that private landowners who are willing to participate would receive market-rate returns on their real estate investments and the transaction would allow the purchasing agency to manage the properties with consideration for the effects of sea level rise. State, federal, or local governments would fund the purchase of properties in hazardous areas, perhaps through a municipal bond, with an emphasis on areas that will be inundated by rising tides within a few decades. The property would then be leased back to the original owner or others until it is destroyed, eroded, or frequently submerged by rising tides. Ideally, a 30-year mortgage could be paid in full by the time the property is damaged by severe sea level rise and or/storm events. However, the Vulnerability Assessment determined that a large coastal storm could damage oceanfront property in the county at any time and, thus, there is some inherent risk

for the purchasing agency. This may also be a viable option for agricultural properties located near the coast.

- Transfer of Development Rights: Landowners of coastal property located in hazardous areas could become "TDR sending areas" and sell unused development potential from vacant lots in exchange for agreeing not to develop their property in the future. Areas inland that are designated to accommodate future population growth could be "TDR receiving areas" where developers pay for the right to develop at a density in excess of the amount allowed by underlying zoning. This type of program is usually used to conserve rural or undeveloped property that is under pressure to be developed due to urban sprawl and rapid population growth, but it could also be applied to areas that will be exposed to sea level rise.

  In the unincorporated areas of Ventura County there are obstacles to using transfer of development rights. To start, there is little unused development potential on the coast, and any unused development rights are highly-valued. Coastal transfer of development right programs have the tendency to require high startup costs and high transfer ratios due to the expense of coastal development rights, although the cities of Oxnard and Malibu have successfully used transfer of development rights programs to retire nonconforming ocean front lots.[34] There are other limitations relative to identification of suitable receiving areas that could accommodate the additional development potential. The County's Existing Communities are mostly built-out and there is little remaining development potential. Also, neighboring cities may be reluctant to agree to receive additional density and development from the unincorporated area.

- Easements: An easement creates a legally binding interest in a property that is recorded with the deed and granted to a third party by or on behalf of the landowner to protect or enable someone other than the landowner to use the land in a specific way. Easements are commonly recorded for properties that require access for utilities or have shared driveways among neighbors. When privately-owned land is identified for conservation or includes unforeseen hazards, an easement can be used to retain the land predominately in its natural, scenic, agricultural, forested, coastal access/recreational, or open space condition. In Ventura County, agricultural conservation easements have been used to compensate farmers for allowing periodic flooding and for agreeing to restrict future development on agricultural land. Rolling easements, that allow for erosion and habitat transgression to occur are also frequently recommended to facilitate nature-based sea level rise adaptation of large parcels. See South Coast Strategy SC-7 for more information about easements that could improve agriculture resiliency.

- Conditions for Removal of Armor: Statewide, from September 2010 to April 2018, the Coastal Commission issued 160 permits authorizing residential construction on ocean front property. Of those, 139 permits were conditioned to include a "shoreline waiver" that requires the applicant to forfeit the right to build a shoreline proactive device.[35] Generally, this strategy by the Coastal Commission conditions new development that is built in a hazardous location to be removed or relocated if, for example (1) any government agency with relevant authority and jurisdiction has ordered that the structures are not to be occupied due to hazards, or are to be removed; (2) essential services to the site can no longer feasibly be maintained (e.g., utilities, roads); (3) removal is required pursuant to adopted LCP policies for sea level rise adaptation planning; or (4), the development

[34] Pruetz, Rick; *Beyond Takings and Givings*; February 2003.
[35] Coastal Rights Coalition vs. California Coastal Commission, Case No.: 30-2018-00994285-CU-WM-CJC, May 22, 2018.

requires new and/or augmented shoreline protective devices that conflict with LCP or relevant Coastal Act policies. In addition, permits could include a condition stating that the development approval does not allow it to be sited on public trust lands, such as the shoreline located below the mean high tide line, and that any future encroachment must be removed unless the Coastal Commission authorizes it to remain. The boundary for the public trust lands will shift landward as the sea level rises, and private development that is located on Public Trust lands may require leasing approval by the State Lands Commission (or other trustee agency).

Impacts: In addition to the impacts described above for Voluntary Managed Retreat, many of the adaptation measures listed above would facilitate retreat on a site-by-site basis, which due to different timelines and varying types of adjacent development, may alter the shoreline in ways that are difficult to predict from a regional planning perspective. Buffers are commonly used to conserve resources or minimize impacts, but may result in non-conforming structures on parcels that were previously developed before implementation of the buffer. Non-conforming structures that are "grandfathered" without having to conform to current standards fall short of implementing the intended regulations. In-lieu fees for mitigation require extensive analysis to implement, are often challenged, and can also require significant time to allocate for mitigation projects.

Cumulative effects: These tools can be effective mechanisms to reduce the amount of development that could potentially be exposed to coastal and flood hazards, and to gradually transition development inland. However, most of the coastal land in the unincorporated area is either already developed or protected from development by the voter-approved initiative called "SOAR". The repetitive loss programs would be less extensive than other items on the above list in the sense that specific parcels would be addressed on the most-vulnerable sites. The conditions for armor removal appear to be an effective measure currently used by the Coastal Commission, but it would be controversial to implement in the County's LCP. Other options would require amendments to the zoning code and possibly the General Plan and would be further evaluated for cumulative impacts before adoption. If methods that reduce development potential in hazardous coastal areas are institutionalized, they could also potentially be applied to other hazardous areas of the County, such as landslide-prone areas of the La Conchita community.

Long-term adaptive capacity: High. This strategy would directly reduce the amount of development that could be located in hazardous areas, therefore reducing the potential impacts on life and property. Out of the various tools listed above the buffers would require approximately one to two years to evaluate and complete the necessary LCP amendments. An in-lieu fee would require more time to conduct a nexus study to defensibly establish the fee amount and develop an administrative framework for gathering and allocating the funds. The repetitive loss program could begin as soon as an agreement is reached with landowners, and it could be administered in partnership with FEMA without the need for LCP amendments. Funding to reduce development potential through market-based mechanisms such as purchase with leaseback, transfer of development rights, and the purchase of easements, is typically costly to start-up and administer. However, if any of these regulatory mechanisms are successfully funded, planned, and implemented, they all could be effective through over 5 feet of sea level rise.

Bridges, Roads and other Major Infrastructure Design (Strategy CW-10)

The general life expectancy for bridges and other major infrastructure is intended to be 100+ years and therefore any new bridges are likely to be in use when the sea level has risen by at least 5 feet, or possibly even more than 10 feet under the worst case, "H++" extreme sea level rise scenario. Substantial modifications or a replacement are being considered for the County-owned Harbor Boulevard bridge over the Santa Clara River on the Central Coast. The Pacific Coast Highway bridge at Sycamore Cove on the South Coast will be replaced by Caltrans (Photo 3-1). In addition, the Highway 101 culvert at Rincon Creek has been identified as a significant barrier for aquatic species and is recommended for retrofit to allow for Southern steelhead trout, lampreys and other aquatic wildlife to travel up the creek from the estuary. Emma Wood State Park, near the County/Ventura City Boundary, is also an area of special concern due to the conglomeration of bridges, roads, a rail line, and utility infrastructure (Figure 2-4).

The design and features for these bridges should accommodate sea level rise and address the following: sea level rise effects, wave transformation, wave run-up on coastal structures, short/long-term beach evolution, sediment discharge, estuary hydrology, aquatic and terrestrial connectivity for wildlife, recreational access, potential tsunami impacts, and coastal structure susceptibility. Additionally, new bridges should be improved when they are replaced to include the following: pedestrian and bicycle access, reinforcements to allow 50-year fire debris flow, culverts that can withstand increased fluvial flooding and storm flow, and the use of construction methods that limit impacts on estuaries and other sensitive habitat, such as pre-assembly of materials outside of sensitive areas. In addition to designs that would accommodate future sea level rise conditions, relocation or alternative routes should also be considered. Most of these projects would require coordination with outside agencies such as Caltrans, the Union Pacific Railroad, the Gas Company, the oil purveyors, and State Parks. Any new major infrastructure should be considered carefully under the maladaptation lens to ensure that it does not increase the number of facilities that are predicted to be exposed over the long-term.

Impacts: The design, engineering, and construction costs to improve or replace bridges and other major infrastructure will increase because they may require additional height, deeper foundations and could potentially be sited further inland. However, by incurring higher development costs now, assurance is provided that the structure can perform adequately through the course of its planned lifetime and greatly reduce the chances that the structure will be severely damaged or destroyed. In addition, increased routine, long-term maintenance costs associated with bridges and other major infrastructure that were not designed to accommodate higher sea levels will be avoided, such as larger armor stone that would need to be used to reinforce revetments that protect roadways from increased wave exposure.

Cumulative effects: Through planning for the effects of sea level rise in major infrastructure improvements, essential services will continue to be available through the anticipated 100-year lifetime of the structures. In addition, those improvements will help increase the overall connectivity of habitats and minimize barriers to species dispersal and migration.

Long-term adaptive capacity: Moderate. This strategy would ensure that key infrastructure performs through the course of its anticipated lifetime. To a large extent, transportation agencies such as the County's Transportation Department and Caltrans will be responsible for the improved design, which could require sea level rise amendments to their respective design manuals and capital improvement plans.

Photo 3-1: Sycamore Canyon Bridge located on the South Coast is 80+ years old and needs to be replaced. The new bridge will be built at a higher elevation.

North Coast

The North Coast is nearly entirely armored with different types of shoreline protective structures in various conditions that shield a wide variety of private and public development and infrastructure from large waves. These structures primarily consist of rock revetments, bulkheads, and concrete seawalls. Except for Rincon Point, the beaches that draw many visitors to the North Coast are in front of rock revetments. The beach widths vary extensively by season and are therefore difficult to monitor (Photo 2-2).

Given the existing shoreline configuration with protective structures and topographic constraints, major transportation corridors and other infrastructure, retreat from sea level rise would be prohibitively expensive in most instances along the North Coast. While the sea level rise models show that most of the armor on the North Coast begins to be regularly overtopped with about 5 feet of sea level rise, when combined with coastal storms, large swells, and runoff from precipitation, the areas that the armor protects will be damaged by high tides and weather events much sooner than 5 feet of sea level rise. Eventually retreat and relocation may be necessary.[36] In the interim the North Coast could benefit from a regional coastal armoring strategy that combines consistently designed neighborhood-scale armoring with the development of sand retention structures to enhance the narrow existing beaches, reduce the footprint of existing revetments, and continue to provide coastal access. A combination of beach nourishment, sand retention, and carefully-designed armor could reduce long-term maintenance costs to the shoreline protective structures and improve coastal access and recreation in the short to medium term.

The exception to this strategy is the residential community at Rincon Point. The homes along the shoreline are currently unarmored. The community was built in an area that is known for a world-renowned surf break, and it includes trees historically used as Western monarch overwintering roost sites as well as a small creek estuary that has historically supported various protected species. Nature-based measures such as, opportunistic sediment nourishment with appropriate cobble and sand grain sizes to conserve the natural state of this headland should be considered. Purchase of the most vulnerable structures could also be a consideration. But as the Coastal Act allows use of armor to project existing structures, the shoreline

[36] Modeling of coastal erosion along the North Coast was not available and thus the potential damages that could occur if the existing armoring is undercut by erosion are underestimated in the Vulnerability Assessment Report.

may eventually be armored, possibly to the detriment of the surf break. After review of the Vulnerability Assessment and other studies, potential adaptation strategies for the North Coast are described below. Note that these strategies may be considered in the North Coast region in addition to the County-wide strategies described above. These strategies are not listed in any order nor are they prioritized. Each description also includes a brief analysis of the potential impacts, cumulative effects, and the long-term resiliency of the strategy or the "long-term adaptive capacity". These topics were described in the introduction to Section 3.

Photo 3-2: A wave hits seawalls at Faria Beach during a coastal storm.

Coastal Armor (Strategy NC-1)

With the distinction of having one of the most armored coastlines in California, shoreline protection is a key issue for Ventura County. Most of the County's armor can be attributed to rock revetments built to protect Caltrans' roadways such as Highway 101 and Old Coast Highway that provide critical access routes to area residents and businesses. Small residential communities along the coastline that are armored also protect Highway 101, Old Coast Highway and the utilities that are aligned with the roads.

Overall, it is difficult to envision how and to what extent the County could efficiently guide the use and design of shoreline armor. On the North Coast, coastal armor along Highway 101 and Old Coast Highway appears to be located within the right-of-way and thus is largely exempt from the County's land-use control pursuant to Section 30600(e)(2) of the California Coastal Act. Discretionary permits that allow the County to have more control over the project design are required if modifications require roadway expansion outside of the existing right-of-way.

Private seawalls are a complex issue to address. Section 30235 of the Coastal Act allows use of armor to protect coastal dependent uses or "existing development" or public beaches that are vulnerable to coastal erosion provided they are designed to eliminate or mitigate adverse impacts on shoreline sand supply. Additionally, Section 30253 of the Coastal Act also requires that new development minimize risks to life and property in areas of high geologic and flood hazard, and not require the construction of protective devices that would substantially alter natural landforms. Sometimes armor is installed during a severe coastal storm event through the issuance of an emergency coastal development permit, and later it is either removed or formally authorized through a follow-up coastal development permit. Emergency permitted structures that are not permanently authorized may face an enforcement fine of up to $15,000 per day. If any element of a revetment or seawall is located below the mean high tide line, it is outside of the County's jurisdiction and the Coastal Commission and State Lands Commission become the lead agencies responsible for permit review and authorization.

During outreach, some North Coast residents expressed interest in identification of a consistent approach to shoreline armoring for contiguous shoreline segments. Often an individual armoring upgrade permit can require tens of thousands of dollars in technical studies, boundary surveys, and engineering, and still be denied. Given the extensive nature of armoring along the North Coast, a consistent neighborhood or shoreline segment approach to armoring could be achieved through homeowner associations, or formation of neighborhood armoring associations and private Geological Hazard Abatement Districts that would be responsible for funding, constructing and maintaining the armoring. The permitting process could also be simplified to provide an economic incentive for neighborhood-scale protective devices that provide similar aesthetic approaches and public access. For example, the rock revetments protecting the communities of Seacliff and Solimar are owned by the respective homeowner associations and may provide an opportunity to apply a uniform approach. In 2015, Seacliff, following an agreement with the State Lands Commission, repaired its entire 2,040-foot-long revetment and agreed to consolidate the number of beach access stairways on the structure. At Solimar, the age and condition of segments of the approximately 4,000-foot-long revetment varies considerably and some segments need repair.

Design preferences could be assigned to specific types of armor, such as recurved seawalls that dissipate wave energy, reduce wave overtopping, use less beach area than revetments, and reduce reflected wave energy that would otherwise alter nearshore processes and/or exacerbate active erosion and sediment transport (Photo 3-3). Another option could include design of revetments that have minimal footprints and maximize wave energy attenuation. Development of in-lieu fees for sand mitigation, public beach encroachment, and ecological values could continue to be included as conditions of permit approval with funds going into an adaptation fund administered by the County or a third-party agency. Maintenance/removal bonds that are posted prior to construction could also potentially be leveraged to ensure adequate maintenance and removal if the structure becomes a public nuisance.

Photo 3-3: Example of a curved seawall.

Impacts: Seawalls and revetments tend to have two main impacts: placement loss and erosion. Placement loss is the area of the beach that the footprint of the structure occupies. Beaches are sometimes buried under rocks following construction of revetments. Revetments are often built at a 2:1 slope meaning that a 20-foot-high revetment occupies 40 feet of beach, which degrades coastal recreation and beach ecosystems. Both placement loss and erosion tend to narrow the beach and affect beach access and recreation. State guidance suggests that the loss of public beaches as a result of shoreline protective devices for private property is an environmental justice issue that should be remedied.

In some cases, the armoring may increase longshore currents, increasing the rate of beach loss in front of the structure, and escalating the erosion rates along adjacent unarmored sections of the coast. Active erosion refers to interactions between the coastal armoring and the physical processes that increase the erosive forces. Some of these processes can include wave reflection, positive wave interference which causes waves to get bigger before breaking, and increased beach scouring. Active erosion is typically site-specific and dependent on the length of structure, sand supply, wave direction, specific design characteristics, and other local factors. As the structure interacts more frequently with waves during more of the tide cycle, active erosion causes scour and increases maintenance costs to the armoring structures. There is some debate in the scientific literature, particularly in areas where sediment transport direction can reverse, but there are clear indications in the Santa Barbara littoral cell of active erosion causing increases in longshore currents and erosion hotspots (Revell et al. 2008).

Passive erosion reduces the beach area between rising seas and a non-erodible coast. The effect of this migration will be the gradual loss of beach in front of the seawall or revetment as the water deepens and the shore face moves landward while the backshore cannot erode. While private structures may be temporarily saved, the public beach is lost. This process of passive erosion is a generally agreed-upon result of fixing the position of the shoreline on an otherwise eroding stretch of coast and is independent of the type of seawall constructed. Passive erosion will eventually destroy the recreational and sandy beach habitat area unless the shoreline is continually replenished. Excessive passive erosion may impact the beach profile such that shallow areas required to create breaking waves for surfing are lost.

Each of these impacts significantly disrupt the ecological function of beaches. For example, invertebrate communities associated with beach wrack deposits (which are a critical resource to foraging shorebirds) are lost. In addition, the increased erosion and tidal inundation from sea walls create unsuitable habitat for species like the California grunion which require sandy areas above the monthly high tide line to spawn every year.

Cumulative effects: In natural settings with erodible shorelines, beaches can migrate inland, but where there are roads and other forms of existing development, coastal armoring obstructs the natural migration pathway and beaches cannot retreat. Protective devices may also block wildlife movements between and among adjacent habitats and cause the overall loss of sandy beach habitats that many species rely upon such as the California grunion or shorebirds. Armor is also aesthetically unappealing, and if the height is increased, it may obstruct views from the residences that it is designed to protect. Maintenance is typically required every 15 years or so, and the costs can escalate rapidly depending on the condition of the structure and if any modifications are required. Specially engineered features designed to mitigate for the loss of beach access are also more expensive. Homeowner associations could form hazard abatement districts to assess their units for armor improvements, but this practice may lead to increasingly privatized shorelines.

Long-term adaptive capacity: Low. While proven to be effective, the armoring strategy has limited ability to adapt without significant changes, costs, and engineering. Revetments along road rights-of-way are costly to remove and replace, realign, or elevate. The County cannot require the formation of the special districts needed to design neighborhood-scale armor unless public health and safety is at risk. Efforts to streamline the permit

authorization process may not be supported by the Coastal Commission because the State guidance seeks to dissuade use of coastal armor. In addition, this is not a strategy that supports the long-term adaptive capacity of the beach ecosystem.

Sand Retention Through Non-Permanent Perpendicular Cross-Shore Features (Strategy NC-2)

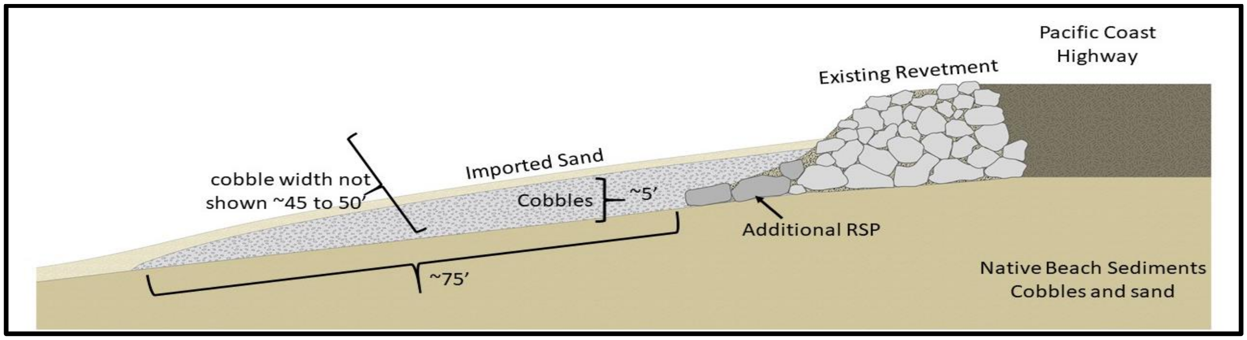
The nearly unidirectional longshore sediment transport along the North Coast makes sand retention relatively feasible and effective. Sand retention works by impounding sand upcoast of the structure and widening the beach. This could be done using traditional techniques such as groins, or by using more innovative, nature-based approaches such as erodible cross-shore cobble berms. Boulder-size rip-rap groins are generally aesthetically unappealing, impede access, and permanently alter the configuration of the shoreline. Historically, boulder-based groins have been found to cause downcoast erosion impacts due to the large amount of sand impoundment. According to a California Natural Resources Agency report,[37] cobble berms and sand dunes are the only types of natural shoreline infrastructure that are suitable for the open coastline in California. Since the beaches along the North Coast are too narrow to develop significant dune systems, cobble berms that are shaped like groins may be the only short-to-midterm nature-based adaptation strategy suitable for this area. However, feasibility studies from technical experts would be needed prior to moving forward with this untested, more progressive nature-based approach.

Cobble-based groins are suitable where cobble is a naturally occurring feature and on the North Coast would be designed to be incorporated with the armoring strategy so that the cobble-groins could be anchored into the revetments and help to mitigate impacts to beach widths and recreation while reducing maintenance costs, as shown in Figure 3-2 below. They would be covered by sand that is either imported or when sand accretes during the summer and fall. These sand retention structures should be pre-filled (a.k.a. charged) with sediment to continue the downcoast littoral drift unabated and minimize the risk of downcoast erosion impacts. It's believed they would function for 2-5 years, depending on coastal storm events. As the cobble groins break down, the cobbles would be reincorporated into the natural supply of cobbles along the back of the beach.

This strategy would require coordination with the Coastal Commission, Caltrans, and County Parks to identify a case study site to construct a few non-permanent sand retention cobble structures. If the strategy performs well, it could be used to mitigate erosion on both North and South Coasts. Funding for sand retention structures could come from FEMA pre-disaster mitigation funds and adaptation grants to reduce maintenance costs for Old Coast Highway. During literature review for this report, cobble groins were the only nature-based alternative to shoreline armor besides retreat that could be used for high-energy wave environments with little space along the shoreline.

[37] Newkirk, Sarah et. al.; Toward Natural Shoreline Infrastructure to Manage Coastal Change in California; August 2018.

Figure 3-2. An ephemeral cobble groin could be constructed of sand and cobble that can naturally erode.



Impacts: Shore-perpendicular structures, such as groins and harbor jetties, tend to trap or impound sand. The subsequent downcoast erosion that could result from such installations can be offset if the sand retention structures are pre-filled with sediment, allowing the continued drift of sand downcoast and minimizing the risk of downcoast erosion impacts. As a type of sediment that would be deposited on a beach, albeit in an engineered manner, there would be temporary construction impacts to the native organisms as described in Opportunistic Sediment Placement Strategy CW-7 above, but these would be short-lived impacts that mimic natural sediment deposition from landslides or flood events. In some sites, though, the beaches are already largely cobble so these impacts would be relatively small. Ideally, these devices would not be placed on existing tidepools and would be designed to allow horizonal public beach access.

Cumulative effects: Permanent sand retention structures alter the natural shoreline, but non-permanent devices have fewer cumulative impacts. The presence of cross-shore features can obstruct horizonal beach access unless specifically designed to accommodate access, such as seasonal sand deposition on top of cobble berms.

Long-term adaptive capacity: Moderate – High. Depends on if permanent devices or cobble groins are selected. Boulder-based groins are proven to be effective, but they also permanently alter the shoreline. Cobble-based groins are a relatively untested device, but they could potentially last for three to five years until reshaping or additional maintenance is required. With maintenance and periodic supplementation of new cobble, these devices could be used as a near- to -mid term strategy for sea level rise and would be optimized by use in conjunction with sand nourishment. Eventually cobble structures would deteriorate and merge into the natural sediment transport system, while boulder groins would be damaged or overtopped by sea level rise, likely prior to or at the same time as other types of coastal armor currently in use are also overtopped. (Also See Appendix B.)

Central Coast

The Central Coast is the most densely populated area of the unincorporated coastline, with single-family and multi-family homes, neighborhood commercial, recreational activities at the Channel Islands Harbor, and recreational day use of Silverstrand and Hollywood Beaches. It is characterized by wide beaches with sand dunes, rivers, marshes, and inland agricultural uses. Other prominent features of the relatively flat topography have pronounced effects on the littoral sand supply and include the Santa Clara and Ventura Rivers, the deep-sea canyon that lies offshore from the Port of Hueneme, and the Channel Islands Harbor.

Sand that travels downcoast from as far as Point Conception eventually settles in this area or drifts offshore. The placement of sand is driven primarily by predominant onshore wind and wave conditions. Sediment dredging maintenance at the Ventura and the Channel Islands harbors, as well as Port Hueneme, is used to nourish local beaches throughout the area until it reaches the main sediment sink--the deep-sea submarine canyon at Point Mugu.

Overall, the Central Coast would benefit from protection from temporary flooding during severe storms using strategies that would re-establish native dune systems to protect residents from tidal and storm flooding. Multi-jurisdictional sand management strategies could be implemented through a variety of means, but a good near-term strategy for the County would be to develop its own beach and dune management plan for Silverstrand and Hollywood Beaches. The City of Oxnard is considering a similar adaptation approach for the Oxnard Shores and Mandalay Bay shoreline communities. An expanded collaborative planning effort between the County and City as the County's plan is developed would be beneficial, and indeed crucial, to both localities.

For agricultural areas adjacent to the Cities of Oxnard and Ventura, near the Santa Clara and Ventura Rivers, the feasibility of a horizontal levee, tidal bench, or other "green solutions" should be evaluated to reduce the inland extent of coastal flood and tidal inundation. These "green" approaches could provide additional areas to accommodate the future transition of habitats while protecting valuable agricultural lands. Any planning efforts that are used to address the projected flooding hazards along the Santa Clara and Ventura Rivers will require a multi-jurisdictional approach, due to the shared-water resources, sensitive species of plants and animals, and the jurisdictional boundaries that bisect these resources. Shoreline armor is not prevalent on the Central Coast, although some revetments are occasionally exposed after 1% annual chance storms.

After review of the Vulnerability Assessment and other studies, some potential adaptation strategies for the Central Coast are described below. Note that these strategies may be considered in the Central Coast region in addition to the County-wide strategies described above. These strategies are not listed in any order, nor are they prioritized.

Re-Establish Native Coastal Dune Habitats (Strategy CC-1)

The wide beaches and onshore wind direction of the Oxnard Plain are supportive of naturally protective sand dunes, which historically supported a large dune field that spanned for miles along the coastline. Low-lying dunes provide a buffer that protects existing development from storm waves, stabilizes windblown sand, and provides important habitat for native species of plants and animals. Coastal development has led to a steady decline in the number of coastal dunes existing in Southern California. To utilize sand dunes as an adaptation strategy to protect adjacent beachfront homes, beach widths of approximately 100 to 200 feet are needed to support successful dune installation and functionality.[38] Silverstrand and Hollywood Beach widths range from 250 to over 1,000 feet, making this strategy and attractive option for these communities because of the benefits provided across multiple resource sectors evaluated (e.g., flood protection, support of natural resources, recreation, tourism, and reduced beach maintenance costs). In addition, these beaches tend to have native seedlings sprout up, showing that the initial formation of dunes

[38] Newkirk, Sarah et al.; Toward Natural Shoreline Infrastructure to Manage Coastal Change in California; August 2018.

occurs naturally when areas are not groomed. This is an indicator that re-establishment of a dune field is likely to be a cost-effective approach for coastal storm and natural resource protection.

Currently, Hollywood Beach is the only beach in the unincorporated Central Coast that still contains a portion of the historic dune field. It is home to sensitive species of plants and animals such as the Western snowy plover, but it has also been degraded by invasive vegetation. The structure of a dune is affected by the type of vegetation that may grow on it. For example, a low-crested, wide hummocky dune is associated with native vegetation such as red sand verbena (*Abronia maritima*), while comparatively wider and much taller dunes are associated with the presence of invasive vegetation such as European beach grass (*Ammophila arenaria*). While dune restoration at Hollywood Beach would require several phases over an extended period, it could begin relatively quickly after community outreach, through permits for nature-based projects, and with relatively low start-up costs (See Appendix B).

Several key aspects would be considered for recreating a protective dune field, including potential ponding of stormwater behind the dunes (Figure 2-6), initial shape and construction, desired elevations and orientation of the dunes, plant species, and potential secondary issues such as coastal access, minimization of adverse impacts on sensitive species, wind gaps, and erosion. Dune management would coordinate maintenance activities such as keeping sand away from residences, maintaining access, and harbor dredging to re-create low-crested hummocky dunes in appropriate areas that protect homes.

Given the jigsaw pattern of jurisdictional boundaries in this area, a multi-jurisdictional approach to dune management would be preferable, involving the County of Ventura, Harbor Department, the Cities of Oxnard and Port Hueneme, and the Navy Base at Point Mugu.

Impacts: Dunes provide ecosystem services that filter water and support rare plants and animals. Dunes planted with native vegetation are not as likely to reduce ocean views from ground floors of ocean front properties and roadways, although without invasive species management, the potential exists. On Hollywood Beach, there may be issues with stormwater drainage, which can be addressed through dune placement combined with storm drain system improvements. While vegetated dunes help stabilize sand, neighborhood nuisance sand abatement may continue to be an ongoing challenge for this area given the dominant onshore wind direction. Low-lying curb walls constructed at the back of the beach may help to reduce wind-blown sand migration from beaches and dunes onto roadways and private property.

Cumulative effects: If the weakest point in a dune system is breached by flooding, substantial damages could occur. Therefore, a comprehensive line of dunes along Central Coast beaches would provide the highest level of protection. In addition, the creation of additional dune fields would significantly benefit many sensitive plant and animal species that are vulnerable to sea level rise by providing additional habitat.

Long-term adaptive capacity: High. There is historic presence of dunes, onshore wind direction and abundant sediment in the Central Coast that is actively managed by the Harbor Department which includes beach grooming, sand removal, and dredge practice management. The project would significantly benefit natural resources and coastal recreation, as well as increase protections to these vulnerable residential communities. Both the Coastal Resilence Model and FEMA coastal flood zone maps suggest that the wide beaches and sand accumulation absorb wave runup and reduce flooding potential. The Coastal Resilience results summarized in Appendix B show that dunes could likely protect existing development from wave flooding through 5 feet of sea level rise. For now, dune restoration should be planned and tested at specific locations such as the existing dune field at Hollywood Beach before widespread application of the measure to other areas.

Dredge Sediment Reutilization for Beach Nourishment (Strategy CC-2)

Maintenance dredging at Ventura and Channel Islands harbors is generally a biennial activity critical to maintaining sandy beaches in the City of Port Hueneme and downcoast to Point Mugu. Dredging is a federal activity completed by the Army Corps of Engineers with federal permits. The existing dredging practices on the West Coast are largely determined by the amount of federal funding allocated by Congress each year. Typically, between one and three million cubic yards of sediment is dredged from the sand trap at the jetty on the northern mouth of the Channel Islands Harbor, and it is mostly deposited near the pier at Hueneme Beach, while about 200,000 cubic yards is also used to nourish Silverstrand Beach. Dredging activity has been ongoing since the Harbor was constructed in 1960.

A six-year program for maintenance dredging was last evaluated by the Army Corps of Engineers in the summer of 2018. When the new dredging programs are proposed, it may be useful to determine if any of the sediment can be used for dune restoration, if needed. In addition to reconsideration of the dredged sediment placement, the seasonal timing and annual availability could be revisited with consideration of sea level rise vulnerabilities. For example, if the operations occurred in early spring then the sediment would be retained on the beaches for the summer and fall seasons when the weather is mild and public access and recreational demand is highest. As the sea level rises, the frequency or intensity of dredging could increase to provide more sediment for opportunistic sediment placement as described in Sediment Bypassing, Strategy SC-5.

Impacts: Lapses in dredging or substantial decreases in dredge bypassing volumes may have downcoast impacts. Dredge operations may adversely impact federally/state protected species that utilize the adjacent beaches and dunes, although impacts to nesting birds and grunion eggs can potentially be avoided depending on the timing of the dredging and sand deposition.

Cumulative effects: An updated approach to dredge sediment management could help maintain protective dunes while supporting adequate downcoast sand supply that will protect all sectors from coastal hazards into the future.

Long-term adaptive capacity: Moderate. There is high adaptive capacity given the abundant sediment

in the Central Coast that is actively managed by harbor dredge practices on the upcoast and downcoast ends, however it is uncertain the degree to which the federal government is interested in modifying its dredging practices for the local harbors and port in order to improve regional coastal resilience.

Photo 3-4: This photo shows nuisance flooding that occurs during high tides at the southern terminus of Victoria Avenue near Hobie Beach in the Channel Islands Harbor. While this storm drain is maintained by the City of Oxnard, residences in unincorporated Silverstrand are located less than 100 feet away.

Storm Drain Improvements for Streets at Hollywood Beach and Silverstrand Communities (Strategy CC-3)

Coastal flooding currently occurs in the densely populated coastal neighborhoods of Silverstrand and Hollywood Beach during large storms (Photo 3-4). At Silverstrand there is nuisance flooding at high tides and seawater stagnates among storm drains that line the only tsunami evacuation route for the neighborhood.

There are three stormwater pump stations at Silverstrand Beach and none at Hollywood Beach. The pump stations at Silverstrand are located on San Nicolas Avenue, Santa Paula Avenue, and Santa Monica Avenue. In a study that was conducted in 2007, the Watershed Protection District noted that, in the dry season, the San Nicolas Avenue Pump Station diverts more water than can otherwise be attributed to urban runoff. The analysis concluded that "seawater-influenced groundwater" infiltrates the storm drain system. This impact will intensify as the sea level rises and further reduce the effectiveness of the stormwater drainage system. Water samples of the outlet at Kiddie Beach found that the concentration of harmful bacteria is significantly higher at high tide, which could also be another harmful effect of sea level rise.

The outlets for two other pump stations were recently upgraded. The outlet pipes on the beach were reduced in length to have less exposure to tides and raised by about 5 feet in order to exceed the height of tides with 4.5 feet of sea level rise and a 1% annual chance storm. However, the pumps will exceed their service life in about 10 years and may need to be replaced in the short-term, which would be a good time to consider additional pumping capacity and higher water salinity.

The County could work with the Channel Islands Beach Community Service District to make the stormwater system more resilient to sea level rise and reduce nuisance flooding. The following improvements could be considered:

- Install equipment such as flap-gates that would restrict tidal flow up storm drains and sand flow into storm drains;
- Waterproof pipes to prevent sea water intrusion—particularly where pumps and electrical equipment are sited; and
- Upgrade and install pump stations as needed to accommodate tidal infiltration.

Impacts: If not properly adapted for sea level rise, storm drains, culverts and pipes could become a conduit for seawater to flow into residential neighborhoods. Modifications and new installations would cause temporary inconveniences to local residents and visitors.

Cumulative effects: If the storm drains are inadequately sealed, or the pump stations fail, the Vulnerability Assessment shows that sea level rise, combined with coastal storm impacts, the high ground water table, and flooding from the harbor could all contribute to inundation at a widespread scale across the Central Coast and adjacent municipalities. Upgrades to the storm drain system that would reduce the hazard risk can be costly, and the system requires ongoing monitoring, maintenance, and repairs. Previous capital improvements were funded through grants, but the life cycle costs of maintaining the facilities were not included. The full costs to operate and maintain pump stations need to be further accounted and addressed as the system is upgraded.

Long-term adaptive capacity: Moderate – High. Pump stations and storm drains alleviate episodic coastal flooding, particularly in conjunction with barriers such as dunes that shield the neighborhoods from wave overtopping. Flooding may begin to reach some shoreline homes along Ocean Drive (Figure 2.5) with 8 inches of sea level rise, but the most substantial upgrades are needed when there are large coastal storms and more than 16 inches of sea level rise. When the sea level rises by 5 feet and daily tidal inundation occurs, the entire system may need to be redesigned to divert outflows to inland areas as sea water intrudes. (Also see Appendix B.)

Seasonal Sand Berms (Strategy CC-4)

Los Angeles County, the City of Carpinteria, and other coastal jurisdictions build temporary sand berms to protect development from storm waves during the winter months. Lifeguard facilities, public restrooms and parking lots are frequently located on the sandy beaches and therefore are the first to be impacted by storm wave runup. On the Central Coast, Silverstrand Beach hosts a lifeguard tower, two public restrooms, and two parking lots, while Hollywood Beach has one public restroom. Beachfront homes could also be protected by a continuous line of berms. The berms would be formed using bulldozers to achieve a ~4:1 slope and the sand could either be sourced onsite or imported. Similar to the large area required to establish sand dunes, at least 100 feet in beach width is needed to supply the sand and construct the berms. Los Angeles County is considering 12 to 16-foot-tall berms on its widest beaches for short-term sea level rise and storm resiliency.[39]

Sand Berms are a relatively low-cost measure that can protect development from medium-sized storms and up to approximately 1 foot of sea level rise. But prolonged storms and north-west swells are likely to erode the beaches and berms alike. During the development of this Report, the berms were a less preferred option compared to dunes because they erode easily and impact beach ecosystems during construction and removal. However, seasonal berms may be a suitable option in areas where permanent dunes are infeasible or opposed by residents, or while a comprehensive dune approach is being planned, developed, and implemented.

Impacts: Construction activities that scrape sand from beaches are harmful to habitat, alter the natural ecosystem, and inconvenience visitors and residents. The designated snowy plover habitat at Hollywood

[39] Los Angeles County Public Beaches, Sea Level Rise Vulnerability Assessment, April 19, 2016.

Beach would make it difficult to permit berm construction, but Silverstrand does not share the designation and has more public assets on the beach to protect. If sand is imported, there are transportation emissions, and site access impacts to consider. Winds can blow the unsecured sediment inland onto private property, roads, and into storm drains. Longshore currents can also carry the sediment downcoast to other areas that don't need the sediment, such as into harbors and ports.

Cumulative effects: The edges of berms are particularly susceptible to erosion. Thus, when gaps or troughs form in the berms, prompt maintenance is needed to fill the gaps to minimize wind and wave erosion. This ongoing maintenance, along with the cyclical construction and removal activities, results in the need to have construction equipment frequently operating on the beach during winter months, exacerbating the impacts described above. When the sand to supply the berms is taken from the lower face of the beach there is a net loss to the littoral cell that is unlikely to be recouped during winter months, and as a result the foreshore becomes less resilient to storms and erosion.

Long-term adaptive capacity: Low. The ephemeral, relatively unstable nature of these devices should be considered against the relative low cost and short timeframe required to plan and build them. Sand Berms are suitable as a short-term adaptation strategy or emergency storm protection measure that can be used until there is a transition to other options such as dunes. It is also worth noting that if the berms are funded through a special assessment district, the assessment fees cannot be increased without an affirmative vote of the members, yet the construction, maintenance, and monitoring costs can increase at any time.

South Coast

The South Coast is a relatively diverse subarea in the county, with agricultural lands reaching inland from Ormond Beach and along the Calleguas Creek at the foot of the Santa Monica Mountains. Ormond Beach is adjacent to the Point Mugu Naval Air Weapons Station which includes beaches, sand dunes, fresh/salt water marshes, and national defense facilities such as an airport. The coastline south from Point Mugu is mostly armored, generally with rip-rap revetments in various ages and conditions that protect a variety of development and infrastructure, particularly Pacific Coast Highway (PCH). The small pocket beaches along the South Coast have historically supported spawning grunion and foraging shorebirds, while historic Western monarch butterfly overwintering roosts may be found in the riparian corridors of the creeks that empty into the sea. In addition, a small creek estuary at the mouth of Sycamore Cove is designated as critical habitat for the tidewater goby. Some of the State Parks property on bluffs near the County boundary at Leo Carrillo remain relatively unarmored but are at risk of bluff erosion.

The South Coast could benefit from a sand retention and sediment bypassing program around Mugu Canyon which would help to nourish and retain sand on beaches. Maintenance of existing armoring could be done in a more comprehensive fashion using Geological Hazard Abatement Districts for private developments, and a Caltrans Corridor Improvement Plan for PCH. In the long-term, inland relocation should be considered for some of State Parks' facilities and portions of the highway where feasible. For agricultural areas along Calleguas Creek and near Ormond Beach, one or more horizontal levees, marsh sills, or tidal benches (see below) could reduce the inland extent of coastal flooding, tidal inundation, and provide some additional elevation to accommodate wetland habitat migration.

After review of the Vulnerability Assessment and other studies, some potential adaptation strategies for the South Coast are described below. Note that these strategies may be considered in the South Coast region in addition to the County-wide strategies described above. These strategies are not listed in any order nor are they prioritized.

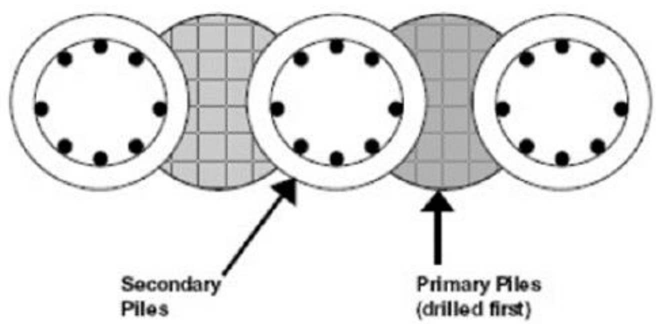
Coastal Armor (Strategy SC-1)

While this topic was covered in the North Coast discussion above, shoreline armoring is revisited here due to its prevalence along the South Coast, primarily in the form of rock revetments that protect PCH. Protective devices, such as revetments and retaining walls, have traditionally been used to stabilize and protect shoreline development from erosion. On the South Coast, some coastal armor along PCH is not located within the right-of-way and therefore has fewer exemptions from the County's land-use control pursuant to Section 30600(e)(2) of the California Coastal Act. The County (and Coastal Commission) have more control when discretionary permits are needed to design and site coastal armor that is located outside of the existing right-of-way on the South Coast.

As the effects of coastal erosion accelerate in this area, Caltrans is concluding that rock slope protection is only a temporary solution in erosion hotspots and is currently planning to use a secant pile wall design for permanent stabilization of the slope and roadway near Sycamore Cove (Figure 3-3). Two secant pile walls are being designed to reinforce rocky headland areas on the north and south sides of Sycamore Cove. Each secant pile will consist of concrete reinforced with steel that is constructed about 100 feet into the ground. When completed, the secant pile wall will extend between 200 and 600 feet long. The design is shown in Figure 3-3 below and consists of piles that are drilled in a staggered formation, followed by another series of piles that are drilled into the gaps between the first set of piles to form a wall. While the revetments are proposed to remain along the toe of the secant walls to dissipate wave energy, secant walls could provide another option for shoreline protection. Also, the final design has yet to be approved, and the Coastal Commission typically requires complete removal of revetment materials when a new seawall is constructed.

Please refer to the North Coast, Coastal Armor Strategy NC-1 for a discussion on cumulative effects, impacts, as well as long-term adaptive capacity.

Figure 3-3: Typical Schematic of a Secant Pile Wall (Source: Caltrans VEN-1 Permanent Slope Restoration Project Initial Study, October 2018)



Standards for Bluff Setbacks (Strategy SC-2)

This strategy addresses sea level rise hazards through increased setbacks. Setbacks would likely apply to bluff-top development that could be severely eroded near the County line of the South Coast. Setback calculations could be expanded to include not only historic rates of erosion, but also acceleration of the erosion rates due to rising sea levels and an additional factor of safety to account for the potential failure widths associated with distinct storm erosion damages.

Impacts: Setbacks eventually lead to the structures still being at risk as erosion continues to impact the properties. Historically significant structures could be prohibitively difficult to elevate or setback, but there are not any registered landmarks on the shoreline of the unincorporated area.

Cumulative effects: Increased setbacks will require departure from any “string line” approach and affect views of the ocean from new development that is set farther back.

Long-term adaptive capacity: Low – Moderate. The setback strategy has limited ability to adapt without significant changes, costs, and engineering. Setbacks are moderately adaptive, although once set, they typically require relocation or reconstruction on the landward side of parcels as ocean front portions are eroded. Overall, there is less than one mile of coastal bluffs in the unincorporated area, and all but one private parcel on the bluffs are already developed; therefore, the most efficient approach could be to develop a long-term managed retreat strategy for the remainder of the bluffs, which are owned by State Parks at Staircase Beach (Figure 2-15).

Standards for Pilings (Strategy SC-3)

A piling is a column of wood, steel, concrete, or other material that is driven into sediments to form support foundations for structures (Photo 3-5). Traditionally, pilings are made from timber with treatments that preserve them in the harsh coastal environment. Modern forms of pilings include reinforced concrete and traditional wood that is wrapped in plastic or epoxy materials. Pilings may be a useful alternative to armor, because they can be used to elevate structures and serve as a foundation for when the footprint of the structure is flooded or inundated. They also are not associated with the active and passive erosion forces that are characteristic of revetments and seawalls. The fewer impacts caused by pilings indicates that they could become a preferable alternative to shoreline armor.

Impacts: Compared to seawalls, pilings accommodate more sand and are more conducive to lateral beach access. However, over the longer term pilings would increase residents’ ability to stay in place as their relative safety diminishes. Inevitably, there would be more beach access if the structures were removed in accordance with the retreat measures discussed above in CW-8 and CW-9. If a new structure is built on pilings, and it is sandwiched between two armored structures, there may be an increase in the erosive forces and scour on the armored structures.

Cumulative effects: Pilings are generally visually unappealing and would alter the character of beaches, but they may provide a transitional design option between continued use of armor and removal of the structure as high-tides encroach inland.

Long-term adaptive capacity: Moderate. The piling design occupies less beach than seawalls, but it accommodates development in hazardous areas. Pilings could be a suitable short-to-mid range strategy on the North and South Coasts, but eventually the rising tides and coastal storms will damage the undersides of the structures. The Central Coast is shielded from coastal storms by the wide beaches, and pilings could be a valuable component of a long-term adaptation plan that includes accommodation of periodic storm flooding. If the Coastal Commission continues to require conditions for removal of armor (Strategy CW-9) an increase in the amount of new development on pilings can be expected.

Photo 3-5: Residence constructed on pilings during a king tide on December 3, 2017.

Sand Retention Through Non-Permanent Perpendicular Cross-Shore Features (Strategy SC-4)

The nearly unidirectional longshore sediment transport along the South Coast makes sand retention relatively feasible and effective. This could be done using traditional techniques such as groins or using more innovate, nature-based approaches such as erodible cross shore cobble berms. According to a recent California Natural Resources Agency report,[40] cobble berms and sand dunes are the only types of natural shoreline infrastructure that are suitable for open coastline in California. Since the beaches along the South Coast are too thin to develop significant dune systems, cobble berms may be the only short-to-mid-range nature-based adaptation strategy suitable for this area.

Ideally these structures would retain sand through the summer and fall months, but since sediment supply to the coast south of Point Mugu is limited, supplementation with sediment from bluffs, inland watershed areas, or through bypassing of dredging sediment around the Point Mugu and Port Hueneme submarine canyons would be helpful.

This strategy would require coordination with the Coastal Commission, Caltrans, and State Parks to identify a few case study sites to construct and monitor the non-permanent sand retention structures.

See the North Coast Strategy NC-2 discussion of cumulative effects, potential impacts and long-term adaptive capacity.

[40] Newkirk, Sarah et. al; Toward Natural Shoreline Infrastructure to Manage Coastal Change in California; August 2018.

Sediment Bypassing (Strategy SC-5)

Presently, the South Coast, east of Point Mugu is in a sediment deficit due to landward migration (headcutting and erosion) at the head of the Point Mugu submarine canyon, which has increased the volume of sand historically captured by this deep-sea submarine canyon. Historical estimates state that 10-15% of sand in the longshore transport used to pass the deep-sea canyons at Point Mugu and Port Hueneme and feed the South Coast beaches, but this amount is now down to 5%.[41]

By developing a sediment bypass program around Point Mugu, more sediment would be available to reduce the coastal hazards along the South Coast and subsequently northern Los Angeles County beaches. The bypassing could be done through revisions to the dredging practices of ports and harbors, in coordination with the Navy Base at Point Mugu to trap sand before it dissipates into the underwater canyon, and through utilization of debris in basins along the Calleguas Creek that would otherwise be carried out with storms to the deep-sea canyon. The Watershed Protection district could partner with the Navy, State Parks, and Caltrans to move the sediment a few miles from Calleguas Creek to an onshore deposition site near Point Mugu.

Impacts: Sediment that is removed from debris basins and trucked to the coast would increase traffic and greenhouse gas emissions, although such activities may result in a net emissions reduction if less revetment rock is transported from distant inland quarries. Speculatively, less sediment entering the deep-sea canyon could potentially increase chances of a submarine landslide and a tsunami.

Cumulative effects: Sediment bypassing on the South Coast would have mainly positive effects such as expansion of recreational beach area, less coastal hazard exposure, and reduced long-term maintenance costs for PCH and State Parks facilities. If sediment is deposited south of Point Mugu, which is at the beginning of the Zuma Littoral Cell, ideally during the early spring when conditions promote on-shore accretion, up to 57-miles of coastline could benefit over time.

Long-term adaptive capacity: Moderate. There is abundant sediment in the Central Coast that is actively

managed by harbor dredge practices, but the volumes needed elsewhere require further examination before new receiving areas are identified. For example, Port Hueneme depends on the dredging deposition to maintain its beaches. Extensive coordination with the Army Corps, the US Navy, and the Coastal Commission would be needed to identify new sites to trap and harvest sand before it enters the deep-sea canyon and therefore, this would be a mid- to -long term strategy. In the near term, appropriate deposition sites can be planned for this strategy as well as opportunistic sediment placement discussed in Strategy CW-7 above.

Horizontal Levee (Ormond Beach or Calleguas Creek/Revolon Slough areas) (Strategy SC-6)

Horizontal levees are generally used to protect urbanized areas from flooding in estuaries and bays and allow room for habitat migration or recreational uses on the gentle slope of the levee. Horizontal levees are a greener alternative to traditional levees and could include crops and orchards (Photo 3-6). Although still experimental in practice along the California coast, a horizontal levee approach would theoretically increase the inland slope along the Oxnard Plain and provide some protection from coastal hazards,

[41] Presentation by Dr. Kiki Patsch; Basics of Coastal Processes Workshop; September 10 to 14, 2018.

particularly tidal inundation and coastal storm flooding. They are generally designed to be three times wider than traditional levees and reach the same height.[42] Such structures could also be used for backshore protection in conjunction with dune restoration, to control and facilitate the migration of wetlands, and provide a buffer between wetlands and agricultural areas. Horizontal levees could be considered as part of an Ormond Beach restoration strategy and could also potentially be applied at the confluence of the Calleguas Creek and Revolon Slough to reduce hazards as well as protect the Navy Base at Point Mugu.

Impacts: The slope may pose problems for certain types of agriculture and for stormwater drainage across the Oxnard Plain. For example, like other levee systems, horizontal levees are designed to control flooding, and areas that are not protected could experience increased flooding as a result.

Cumulative effects: This is one adaptation strategy that may not require extensive maintenance and monitoring by the managing agency because once constructed, horizontal levees are inert earthen structures that have a long expected operational life-time, especially if they are protected from toe scour and are not overtopped by floods. More analysis is needed to determine if any crops could be effectively grown on the gentle slopes of the levees. If not, some cropland would be removed from production to make space for the structures.

Long-term adaptive capacity: Low – Moderate. Horizontal levees have been used in other regions to shore up marshes, wetlands, and stormwater detention basins. The suitability of horizonal levees in conjunction with farmland adjacent to Ormond Beach, Calleguas Creek, or the Revolon Slough would require feasibility studies and additional analysis. Through coordination with the Watershed Protection District, the US Navy, and private landowners, this is a strategy that should be considered before any levees are raised or any additional channelization occurs.

Photo 3-6: This horizontal levee provides a transition area between an estuary and an orchard that includes recreational pathways.

Conservation Easements (Ormond Beach or Calleguas Creek/Revolon Slough areas) (Strategy SC-7)

Rolling easements are frequently discussed as a method to facilitate nature-based sea level rise adaptation. These conservation easements can be designed to allow development in some areas, but not others. The basis of a rolling easement is a “rolling design boundary”, such as a dune vegetation line, that is used to identify seaward areas where development is restricted, and inland areas where development continues to be allowed.[43] On the coast, the developable areas of a parcel may change in response to natural

[42] Hill, Kristina; Coastal Infrastructure: A Typology for the Next Century of Adaptation to Sea Level Rise; 2015.
[43] EPA, Climate Ready Estuaries; Rolling Easements; June 2011.

processes such as coastal erosion or accretion, and a rolling easement can be integrated into an agreement to forgo the use of new coastal armor such as sea walls. Such a program could be used for areas with large contiguous parcels, such as agriculture and undeveloped areas near estuaries, but would be less useful for small parcels with single homes because there are typically few alternative sites for development.

Another type of easement is for agricultural conservation. These easements have already been applied to 480 acres along the Santa Clara River through the Natural Floodplain Protection Program[44] and could also potentially be applied to agriculture in the Ormond Beach and Calleguas Creek watershed areas. Once recorded, the easements prohibit development of stormwater infrastructure such as berms and levees in order to allow non-structural flood control, such as natural drainage into the pervious agricultural soil. This would reduce flooding potential in areas adjacent to the Point Mugu Naval Base. It would also help to offset saltwater intrusion into groundwater tables. However, compared to the Santa Clara River, the Ormond Beach, Calleguas Creek and Revolon Slough areas are expected to experience more tidal flooding, which could impede the ability for farms to accommodate flooding on land used for crop production due to the higher salinity concentrations.

Impacts: Easements are voluntary agreements to compensate landowners in the short-run, and can be combined with the Land Conservation Act Program to reduce annual property taxes, but easements are also likely to lower the value of the property in the long-term. This may be an acceptable tradeoff in agricultural areas that will be less productive as the salinity of the soil increases. As a regulatory mechanism to conserve land, easements do not have any identifiable direct impacts.

Cumulative effects: Easements would help to maintain low development intensity around the Point Mugu Naval Base, which is a pervading goal of the US Navy. They can be recorded on parcels in strategic locations that would optimize natural flood control, allow space for wetland retreat, and restrict future development including engineered flood control devices.

Long-term adaptive capacity: High**.** Once recorded, easements run with the land in perpetuity and are less expensive than outright land purchase. Both agricultural conservation easements and rolling easements can be used in conjunction with planning to develop horizonal levees on private lands. Coordination would be needed with the City of Oxnard, the US Army Corps of Engineers, the US Navy, the Coastal Conservancy, and the Nature Conservancy to determine where rolling easements would be appropriate. This analysis would generally be based on factors such as the projected extent of erosion and the migration of the wetlands, including retreat for sea level rise. The Ormond Beach Restoration and Access Plan may be helpful in estimating how to use easements and other tools to plan for medium- and long-term sea level rise adaptation in the wetland and agricultural areas of the South Coast.

[44] This program is described in Section 1.4 of the Vulnerability Assessment.

3.2 Adaptation Pathways

Reviewing current County programs and policies associated with risk reduction is the first step to identifying potential short-term adjustments to alleviate or eliminate sea level rise risks. Where adjustments to current practices will not sufficiently address the risks, more substantial actions should be identified and implemented in the future.

Of critical importance to the successful implementation of an adaptation strategy is communicating the issues and proposed response strategies to the community. Studies repeatedly show that knowledgeable and prepared communities with educated decision-makers that understand how to respond to extreme events, will be far more resilient. An informed community is also more likely to implement programs and make decisions that proactively plan and prepare for extreme events, and this minimizes potential impacts.

Many of these adaptation strategies take substantial time to implement, and local coastal communities may be hesitant to implement policies that are costly and burdensome to private landowners and resource-constrained public agencies. Identification of a step-by-step approach with thresholds that will trigger pre-determined planning processes can provide a more acceptable, phased approach. Policies and implementation programs in the LCP can help to identify specific thresholds that trigger specific actions. Factors to consider when prioritizing adaptation projects include: public health and safety, available funding sources, legal mandates, planning consistency, capacity and level of service, cost-benefit relationship, environmental impacts, near-, mid-, and long-term effectiveness, and public support. Risks that present the most serious consequences and are projected to occur first should raise a project's level of priority.

Adaptation Pathway Case Studies

To demonstrate how the adaptation strategies discussed above could be applied to some of the vulnerable areas that were identified, this Section provides some examples of possible adaptation pathways that can be used. An adaptation pathway is a planning approach that addresses the uncertainty and challenges of sea level rise decision-making. It considers which adaptation strategies could be effective over the near-, mid-, and long-term, and which triggers could be monitored and used to initiate future planning and implementation of new strategies. It also enables consideration of multiple possible futures and allows flexibility of various options for implementation. The intent of these case studies is to begin a community dialogue and eventually craft policies for updating the LCP. The adaptation pathway case studies presented below were distilled through a five-step process:

1. The process began with a review of vulnerable areas that would be affected first by tidal inundation, as summarized in Section 2 of this report. Tidal inundation was selected as the primary indicator because, although many areas may be flooded temporarily by storms, areas that are tidally inundated will be permanently changed and potentially unusable. Also, the probabilities assigned in the State guidance are only applicable to sea level rise and not to coastal storm frequency, so an approach that focuses on tidal inundation allows for a more precise assessment of risks.
2. Research was conducted to identify feasible adaptation strategies that could be applicable to the land uses in these vulnerable areas. Additional consideration was given to strategies that are already being used or considered in the County and in other jurisdictions.

3. After compilation of available adaptation strategies, recommendations for each planning subarea were integrated into the summaries of viable adaptation strategies in Section 3.2.
4. The updated list of strategies was reviewed during focused outreach meetings with other departments and agencies to determine whether any additional strategies should be considered, and which strategies would be compatible with the missions of other agencies, including other County agencies.
5. After the focused interviews, a basic economic analysis was conducted to evaluate four prioritized adaptation strategies that could be applied to improve the resiliency of public resources and government-owned facilities. This analysis estimated likely construction costs for the adaptation strategies and compared these costs to the value of assets that would be protected. This economic analysis is summarized in Appendix B.
6. The adaptation information gathered through this process was summarized and discussed with a management team from the Planning Department, which resulted in the strategy recommendations described below. This is simply a starting point to begin discussion about adaptation. Before any strategies are implemented, additional coordination and input will be needed from the public, stakeholder groups, the County Planning Commission, the County Board of Supervisors, State and federal agency partners.

Case Studies 1 and 2: Sediment Management at Hollywood Beach and Silverstrand

The Coastal Resilience, CoSMoS sea level-rise models, and FEMA flood zone maps demonstrate that existing development at Hollywood Beach and Silverstrand Beach are somewhat protected from coastal storm flooding by the existing wide beaches. According to State guidance, protection through natural beaches and dunes is preferred for adaptation purposes over the use of shoreline armor. However, the summary of vulnerabilities in Section 2.2 above describes that wide beaches alone are not enough to protect these neighborhoods when there is 5 or more feet of sea level rise (~2100), and because improvements to the Channel Islands Harbor, such as additional bulkheads, will be needed well before that time.

Since the characteristics of Hollywood and Silverstrand Beaches vary, the hypothetical adaptation implementation timelines and cost benefit analyses provided below are slightly different for each location. One of the major differences is that Silverstrand is far more popular for beach visitors and day-users than Hollywood Beach, and Hollywood Beach is home to existing sand dunes that provide sensitive species habitat.

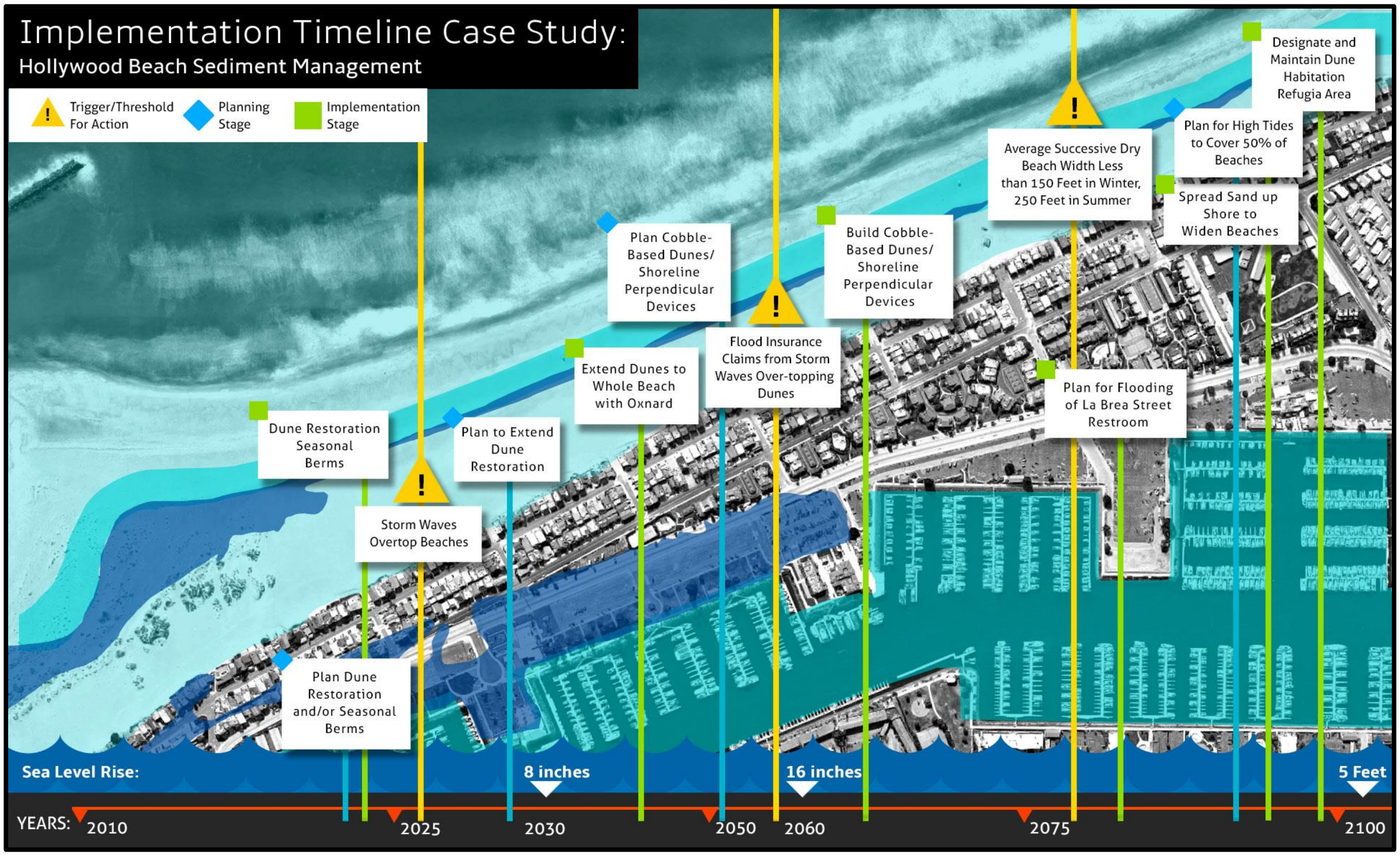
1. Sediment Management at Hollywood Beach

Hollywood Beach is one of the few areas in the unincorporated County where accretion, or build-up of sand occurs over time. These beaches continue to accrete, despite reductions in the amount of sediment carried into the littoral cell, due to the trapping of sand at each of the harbors and the direction of the waves and onshore winds that are characteristic of the Central Coast. Sediment management for Hollywood Beach could include the following components that are also illustrated in Figure 3.4 below. The strategies that are numbered correspond with the descriptions in Section 3.1 above.

- **Before 8” of sea level rise.** In the near term, existing sand dunes near the harbor jetty sand trap could be restored to remove invasive species and improve drainage (Strategy CC-1). While monitoring the dune restoration, other areas along the beach could be considered for building seasonal sand berms in front of homes for some protection from winter storms. Potential triggers for implementation of the next adaptation strategy could occur when coastal storm flooding reaches the homes that lie behind the existing dunes and any seasonal berms are eroded. Appendix B discusses the economic costs of building and maintaining sand dunes using different construction methods.

- **Between 8" and 16" of sea level rise.** If the dune restoration is successful, the project could be extended along the remaining Hollywood Beach shoreline, and through coordination with the City of Oxnard, further upcoast along Oxnard Shores. Given that sand naturally accretes in this area, sand fencing and other low-cost barriers could be used to begin to create new dunes. New dunes could also create or expand sensitive habitat, leading to the need for planning for protected species, public access, stormwater runoff, and the maintenance dredging area. Potential triggers for implementation of the next adaptation strategy could occur after coastal storm flooding overtops or erodes dunes and damages the homes that lie behind the existing beach dunes to the extent that there are flood insurance claims.
- **Between 16" and 5' of sea level rise.** When dunes are destroyed by a storm, they could be rebuilt with more resilient materials such as cobble foundations with deeply buried toes. These dunes would be more expensive to construct, but may last longer than sand-based dunes that accrete using simplistic collection devices. The restroom at the end of La Brea Street should be planned to accommodate coastal storm flooding. A possible trigger to implement the next adaptation strategy could be when the beaches decrease by a significant width for successive years, and before they become too narrow to support dunes, as measured according to the mean high tide line, by 150 or 200 feet. (See Figure 3-4 below.)
- **5'+ of sea level rise.** If the beaches are eroded in the long-term, consider how much of the sand trapped sediments can be used as a source to restore backshore dunes along the remainder of Hollywood Beach (Strategy CC-2). A high-lying beach area located inland of the sand trap that is partially protected from storms by the breakwater should be designated as a refugia for dune habitat (Strategy CW-5). If the beaches begin to be overtopped by waves, it would be prudent to have employed adaptation strategies for the residential areas, such as raised development designed to accommodate flood water.

Figure 3-4: Hypothetical Adaptation Pathway Case Study for Hollywood Beach Sediment Management. Note that the yellow-colored line representing a "Trigger for Action" would initiate the next phase of adaptation measures.



2. Sediment Management at Silverstrand Beach

In contrast to Hollywood Beach, Silverstrand has only fragmented remnants of sand dunes and much higher rates of recreational use, including a popular surf break. The beach is narrower than Hollywood Beach, and can be less than 200 feet in width at times. The southern end of Silverstrand Beach is periodically replenished when the sand trap at the Harbor Jetty is dredged. Assets on the beach include a lifeguard tower and one parking lot on the north end of the beach, and a restroom and a parking lot on the south end of the beach. Sediment management for Silverstrand Beach could include the following components that are also illustrated in Figure 3-5 below.

- **Before 8" of sea level rise.** In the near-term, seasonal sand berms could be used to protect residences during winter storms. In the calmer summer months, the berms could be removed, improving beach access and views from the first floors of residences. Planning for resiliency of the lifeguard tower and parking areas should also be considered during this time. Possible triggers to plan and implement the next adaptation step could be when the seasonal berms are eroded by storms, when wave flooding reaches the streets during a storm event, or when a minimum beach width threshold is triggered for successive years.

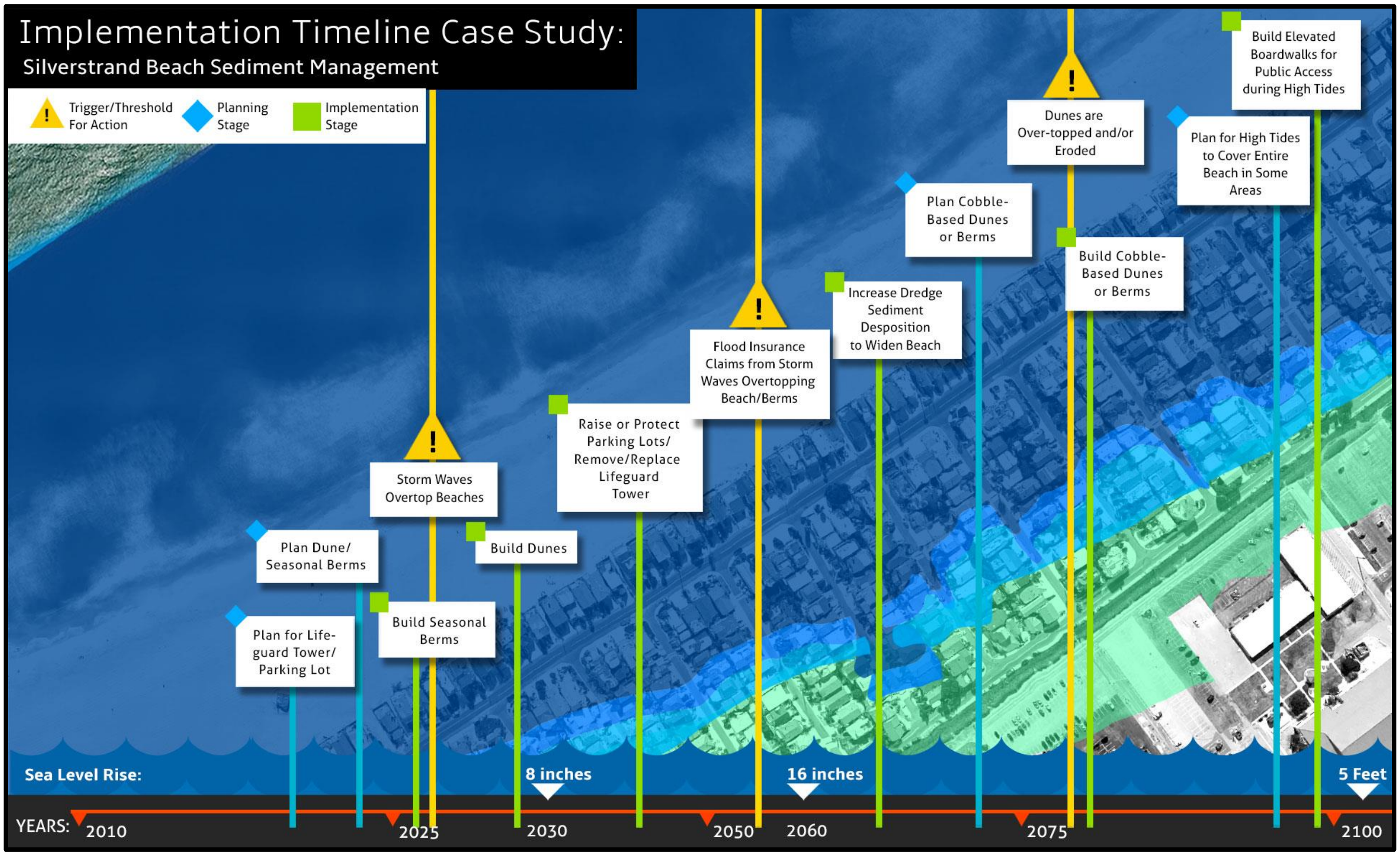
- **Between 8" and 16" of sea level rise.** In the mid-term, when the effects of sea level rise begin to increase, and there is more exposure to storm waves and erosion, the beach width may need to be maintained or increased through enhanced dredging sediment deposition, or seasonal berms may need to be rebuilt with more resilient materials such as sand dunes or berms with cobble foundations. These engineered structures that mimic naturally occurring sediments theoretically erode slower than sand alone and they could provide ecosystem services if they are covered with sand and planted. A perpendicular structure on Silverstrand is not recommended because it is likely to affect the popular surf break. Appendix B discusses the economic costs of building and maintaining sand dunes and cobble-based sediment retention devices.

  As sea level rise is projected to reach about 8 inches, the 25-year planned lifespan of the lifeguard tower will mature, and the effectiveness of project features that were included to improve resiliency will need to be reassessed. These features include a 13.5-foot elevated first floor, deepened perimeter footing, and masonry block construction design. During the permitting process for the tower, the Coastal Commission applied a condition that excludes potential armoring to protect it, leaving only accommodation and retreat as viable options for this facility. The design of the parking lot behind the tower will also need to be reassessed, and either raised, protected, or relocated. Potential triggers for planning and implementation of the next adaptation step could occur after coastal storm flooding overtops or erodes dunes and damages the homes that lie behind the existing beach dunes to the extent that there are flood insurance claims.

- **Between 16" and 5' of sea level rise.** Plan for continued public access when tidal inundation reaches homes at the narrowest areas of the beach. The restroom at the end of Van Nuys Avenue should be planned to accommodate coastal storm flooding. A possible trigger to plan and implement the next adaptation step could be when the dunes or cobble-based sediment retention devices are eroded or destroyed by storms.

- **5'+ of sea level rise.** Continuation of sand deposition from dredging will be needed (Strategy CC-2). If the beaches begin to be overtopped, it would be prudent to have strategies for public access, such as elevated boardwalks and lookout points that would continue to allow horizonal public access when the beaches are inundated at high tide (see Figure 2-9). If the beaches erode, coastal armoring may be needed during emergencies. If the beaches begin to be overtopped by waves ideally adaptation strategies will have been implemented for the residential areas, such as raised development designed to accommodate flood water.

Figure 3-5: Hypothetical Adaptation Pathway Case Study for Silverstrand Beach Sediment Management. Note that the yellow-colored line representing a "Trigger for Action" would initiate the next phase of adaptation measures.



Case Studies 3 and 4: Stormwater Drainage Improvements at Hollywood Beach and Silverstrand Neighborhoods

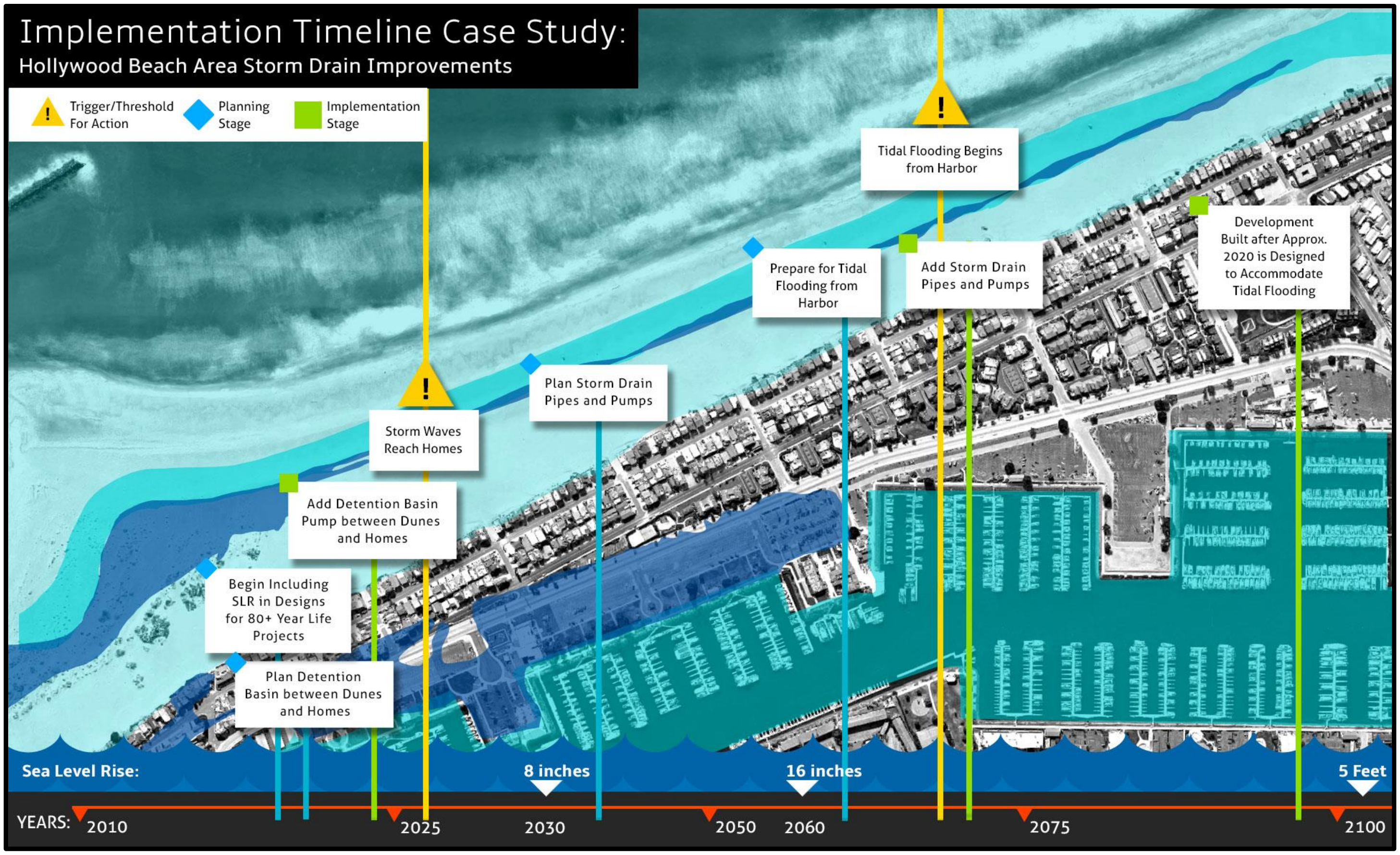
Various forms of Sediment management could advance the "front line" of coastal resilience for the Hollywood Beach and Silverstrand communities (Strategy CW-6), and the modeling results in Appendix B indicate that this activity may provide protection from coastal storms through 5 feet of sea level rise, but a 1% annual chance storm with heavy rains, large surf, and high tides could nevertheless erode and overcome sand dunes and berms on beaches and temporarily flood the neighborhoods. There is also the potential for sea level rise to percolate into areas with high ground-water tables and cause saltwater to pond onto streets, particularly in the Silverstrand neighborhood (see Appendix B). The sea level rise models also show that there are low-points on the shore of the Channel Islands Harbor that should be reinforced before there is about 16 inches of sea level rise. A coastal resiliency strategy for these areas should consider how stormwater management, specifically the stormwater drains and pump stations, can be improved to reduce these flooding risks.

3. Storm Drain Improvements at Hollywood Beach

The storm drain system at Hollywood Beach relies on a gravity-based system of drains and culverts. There are fewer low-lying areas that tend to pond water here than at Silverstrand. The Hollywood Beach system primarily drains through drop inlets with subterranean catch basins that allow stormwater to percolate into the ground. There are also a few detention basins located under the road near Los Robles Street. Improvements to include storm drains and pumps may be needed as the tides rise on three sides of the peninsula and if the underlying sandy soil becomes saturated by rains and tides. Storm drain improvements for Hollywood Beach could include the following components that are also illustrated in Figure 3-6 below.

- **Before 8” of sea level rise.** The developed areas behind the dunes along Ocean Drive may be one of the first areas affected by tidal flooding. Expansion of the existing stormwater system to service this particular area could include adding a detention basin with a pump as a near term measure. Sea level rise projections and accommodation principles such as increased floor elevations and or movable foundations should begin to be incorporated into the design of new houses with an 80+ year planned lifespan (Strategy CW-3).
- **Between 8” and 16” of sea level rise.** Plan funding and implementation for stormwater system improvements on local streets (Strategy CC-3).
- **Between 16” and 5’ of sea level rise.** Between about 16 inches and 5 feet of sea level rise, the Channel Islands Harbor will begin to experience tidal flooding. Coastal storms that periodically flood the area also become more severe. This is the time to implement storm water system improvements, such as additional storm drain pipes and outfalls with flap gates designed at sufficient heights to discharge waters out to the beach (Strategy CC-3). The height of the outfalls would need to be designed to exceed the heights of coastal storm waves and setback sufficiently to withstand erosion during 1% annual chance storms. Consideration should be given to whether to discharge stormwater into the Harbor while it is flooded.
- **5’+ of sea level rise.** With 5 feet of sea level rise, tidal flooding will begin to affect most streets and some developed areas at the end of the peninsula and the elementary school. Risk would be reduced if the storm drain system is designed to convey stormwater to inland detention basins. It may be useful to coordinate with the Harbor Department to explore whether it is feasible to install flood gates to minimize flooding potential from this source. If the beaches begin to fail as a storm barrier, it would be prudent to have employed adaptation strategies for the residential and commercial areas, such as development that is designed to accommodate flooding.

Figure 3-6: Hypothetical Adaptation Pathway Case Study for Hollywood Beach Area Storm Drain Improvements. Note that the yellow-colored line representing a "Trigger for Action" would initiate the next phase of adaptation measures.



4. Storm Drain Improvements at Silverstrand

The storm drain system at Silverstrand includes drop inlets, storm drain pipes, and three pump stations (Figure 3-7 below). The three pump stations are spaced at relatively even distances across Silverstrand, and two with outfalls on the beach were recently upgraded to higher elevations and setback further on the beach berm. The third station is beside the Harbor and sends some initial effluent to a treatment facility, and then it releases the rest to Kiddie Beach in the Harbor. Adjacent to Kiddie Beach, Hobie Beach experiences some nuisance tidal flooding of storm drains today, along South Victoria Avenue, but this infrastructure is within the City of Oxnard's jurisdiction (Photo 2-2). Storm drain improvements for Silverstrand could include the following components that are also illustrated in Figure 3-8 below.

- **Before 8" of sea level rise.** Coordination is needed with the Harbor Department, Transportation Department, and the City of Oxnard to begin planning to reinforce the harbor at Hobie Beach. According to hazard modeling, with as little as about 8 inches of sea level rise and a 1% annual chance storm, the evacuation route through this location that serves the Silverstrand community is temporarily flooded. The County could work with the City of Oxnard to improve the drainage and elevate the roadway (Strategy CW-10) so that tidal inundation that causes nuisance flooding today, does not hinder the ability to evacuate the area when it may be needed in the future (Figure 2-10). Sea level rise projection and accommodation principles should begin to be incorporated into the design of new structures with an 80+ year planned lifespan (CW-3).

- **Between 8" and 16" of sea level rise.** Conduct a sea level rise analysis and review the design of the existing stormwater system, its planned lifespan, and consider modifications that should be included during routine maintenance and planned upgrades to improve resiliency to sea level rise. Such modifications could include elevating and flood proofing pump station electrical equipment, adding detention basins, and extending the length of drain pipes to areas around Panama Drive (Strategy CC-3). Coordination with the Port and neighboring Navy Base will be needed to determine if the existing flood gates on the Port's canal system can accommodate 5 feet or more of sea level rise.
- **5'+ of sea level rise.** Consider modifying the pump station at San Nicolas Road to pump all stormwater to a wastewater treatment facility or other locations inland other than into the Harbor, unless the Harbor is modified to accommodate rising tides and stormwater. If the beaches begin to fail as a storm barrier, it would be prudent to have employed adaptation strategies for the residential and commercial areas, such as development that is designed to accommodate flooding.

Figure 3-7: This diagram shows the stormwater system at Silverstrand that results from modeling water depth during a 1% annual chance storm, not including sea level rise (Source: Silverstrand Pump Stations Deficiency Study, 2014).

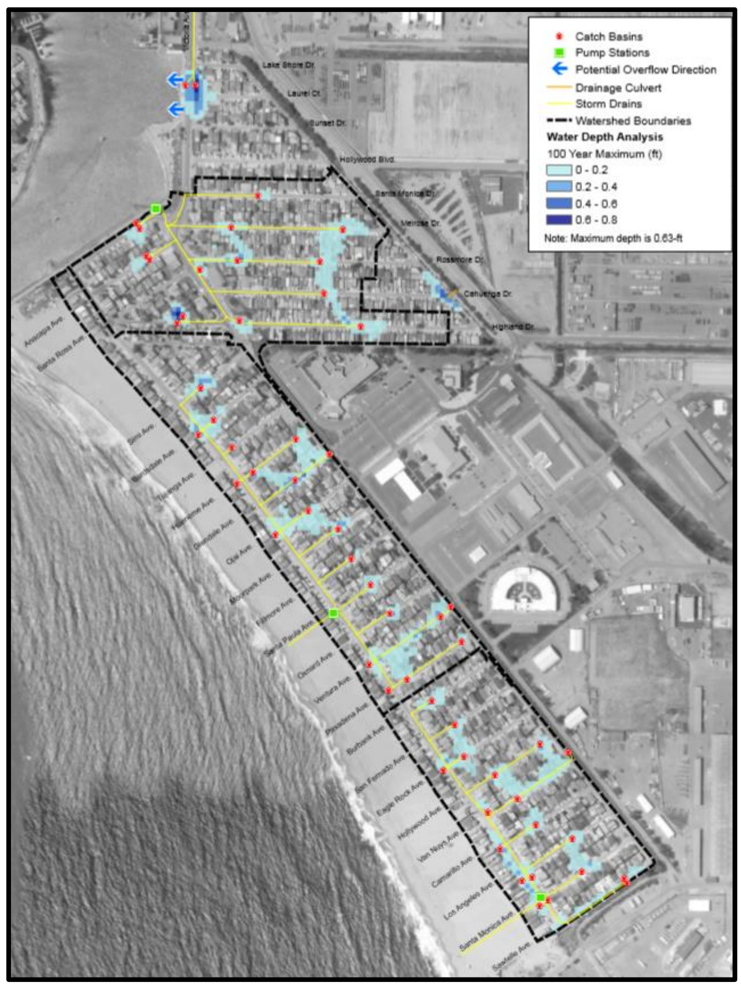
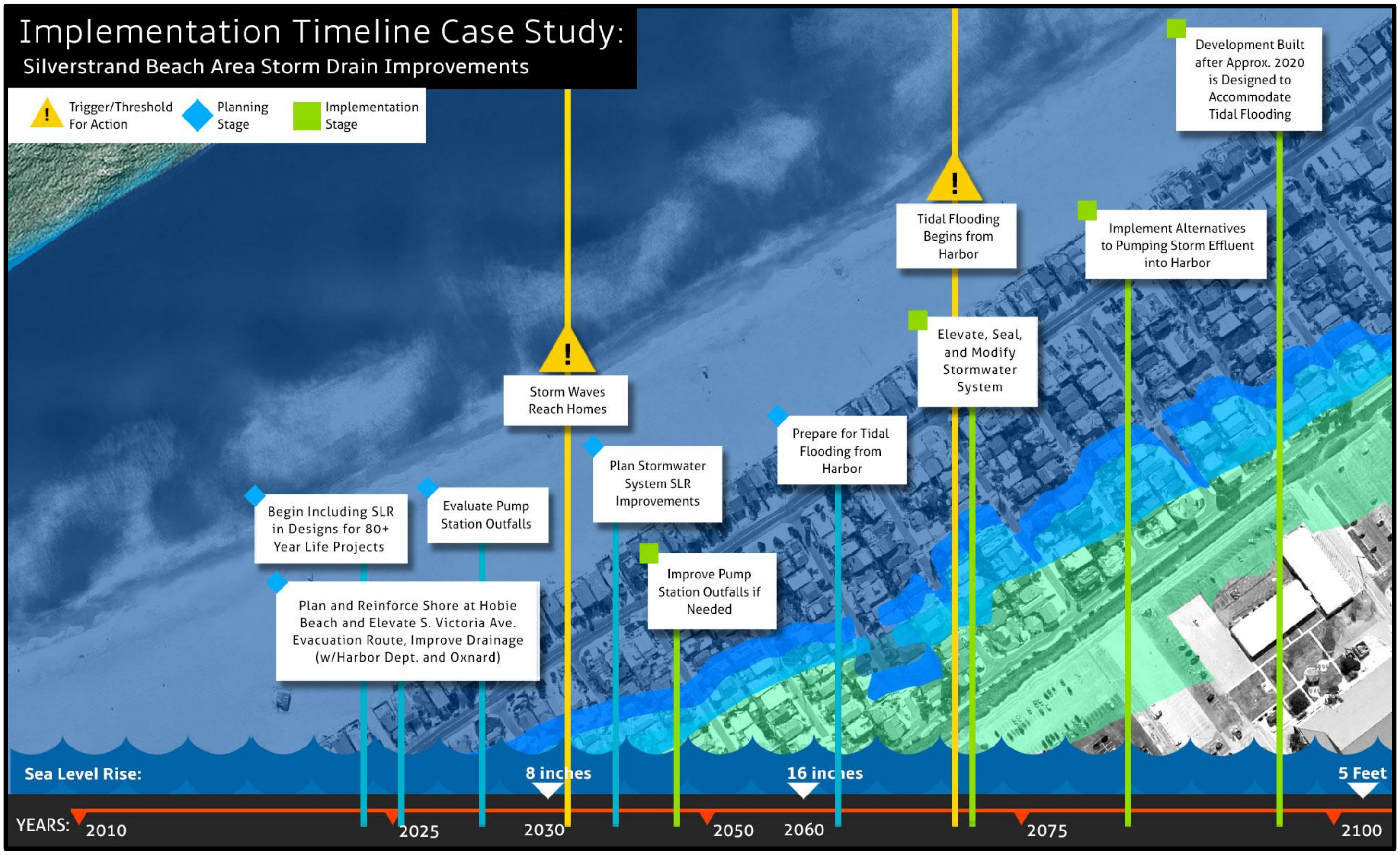


Figure 3-8: Hypothetical Adaptation Pathway Case Study for Silverstrand Storm Drain Improvements. Note that the yellow-colored line representing a "Trigger for Action" would initiate the next phase of adaptation measures.



Case Study 5. Adaptation of the Rincon Parkway, Hobson and Faria County Parks

The North and South Coasts have many coastal access areas that consist of narrow beaches that are backed by shoreline armoring (Photo 3-7). The most popular County-operated public camping facilities, at the Rincon Parkway and at Hobson and Faria Beach Parks, have narrow, seasonal beaches in front of rock revetments. The revetments that line Old Coast Highway on the Rincon Parkway and at Faria Beach Park are expected to withstand up to approximately 5 feet of tidal inundation, with substantial increases in maintenance costs, but Hobson Beach Park may be consistently flooded before this time, and all of these facilities will be closed more frequently with sea level rise and 1% annual chance storms. Any adaptation strategies involving the Rincon Parkway will require coordination with Caltrans, the owner of the revetments along Old Coast Highway.[45] Adaptation plans for these sites could be used as a case study for

[45] The County and Caltrans have a longstanding Memorandum of Understanding that allows the County to maintain and operate public recreational uses along the Rincon Parkway.

areas with similar conditions on the North and South Coasts. Adaptation for the beach parks and the Rincon Parkway could include the following components that are also illustrated in Figure 3-10 below.

- **Before 8” of sea level rise.** Coordinate with Caltrans to construct a pilot project with non-permanent, nature-based sediment retention devices such as cobble-based groins (Strategy NC-2) Another pilot project could include replacement of the revetment at Hobson Beach Park with a seawall that has a smaller design footprint, access stairs and possibly tidepools for nature viewing (Strategy NC-1). Since seawalls increase the rate of beach erosion, it would be optimal to test sediment retention measures in unison with a small-footprint seawall, in order to potentially preserve the beaches for a few more decades.
- **Between 8” and 16” of sea level rise.** In the short- to mid-term, sediment retention and beach nourishment strategies would help to maintain and potentially extend beach widths in front of the shoreline armor. Sand would help buffer the parks and armoring from storms, and the perseverance of dry sandy areas during high tides would benefit recreation and natural resources such as spawning grunion and birds that feed on beach wrack. Beach nourishment could be conducted through various methods (Strategy CW-7). For example, soft coastal bluffs that are prone to slide onto roadways can be pretested for suitability of grain size and for pollutants, potentially allowing for deposition on the shoreline. Or the existing Union Pacific rail line could be used to transport sediment from more distant locations, such as the sediment-rich Central Coast or the County Watershed Protection District’s inland debris basins. Sediment retention could include perpendicular shoreline structures such as permanent rock groins, or nature-based cobble groin projects (also see Appendix B). The North Coast beaches are generally too narrow to accommodate the addition of sand dunes, as consistent year-round beach widths of approximately 100 feet are needed.

  A significant seasonal improvement to enhance access could include the deposition of large amounts of sand to cover the revetments at Hobson County Park (Photo 3-7). The covered revetments would function as sand berms during the summer months. While this sand will eventually erode, most of it would move downcoast, providing a temporary benefit at the Rincon Parkway, Faria and Rincon neighborhoods, and Emma Wood State Beach.

- **Between 16” and 5’ of sea level rise.** Public agencies that maintain public beaches should consider alternatives to rock revetments along narrowing beaches, as the footprint of such structures can consume large areas of sandy beach that could otherwise be used for recreation and habitat. For example, Figure 3-9 below shows a segment of the Rincon Parkway that includes both a seawall and rock revetments. In the aerial image on the right of Figure 3-9, the same amount of space that the revetment occupies is used for camping and parking at the adjacent location where there is a vertical seawall. If all of the RV camping areas were lined with vertical seawalls instead of revetments, about 145,000 square feet of space could be used for 160 additional RV camping sites or for other amenities such as Coastal Trail improvements.[46] A smaller footprint for shoreline armor would also leave space for beach recreational activities and beach wrack that benefits shorebirds and spawning grunion.

[46] The calculation to reach 160 RV spaces estimated that the revetments occupy 14,500 square feet of space per every 0.10 miles of length on the Rincon Parkway. The Parkway is about 1 mile long, and each designated space is about 900 square feet.

Hobson County Park is projected to be the first revetment that protects a park on the North Coast to be inundated by rising tides (see Figure 2-3). This site could become a pilot project for adaptation strategies on the North Coast and it may be the first instance where the decision between retreat and continuing to armor comes to the forefront on public facilities. Retreat would be unlikely unless other sites are found to relocate the park. Instead of having to extend the revetment to be higher and wider, a seawall is likely to be the least damaging option in the long-run, other than voluntary retreat (Strategy CW-8) or closure. As the armor become overtopped, the utilities that run along Old Coast Highway, such as the Service Area 29 sewer line, should be modified so that electrical equipment is elevated and vulnerable inlets are sealed.

- **5'+ of sea level rise.** In the long-term, difficult decisions will need to be made if sea level rise is as severe or worse than expected for these public parks on the coast. The County and Caltrans may elect to raise the heights of shoreline armor, acquire property, or develop partnerships to move the facilities to higher elevations inland of the rail line. Or little to no action could be taken and resources would be expended to address more frequent seasonal closures, and additional cleanup and maintenance costs. Either alternative will increase costs to the County and Caltrans. If reinforcing the armor is chosen, then design standards could be used to minimize the impacts on habitat and to protect public access.

Photo 3-7: Coastal access at Hobson County Park with rock revetments. The Rincon Parkway can be seen in the distance.

Figure 3-9: The Rincon Parkway is entirely armored with rock revetments and seawalls.

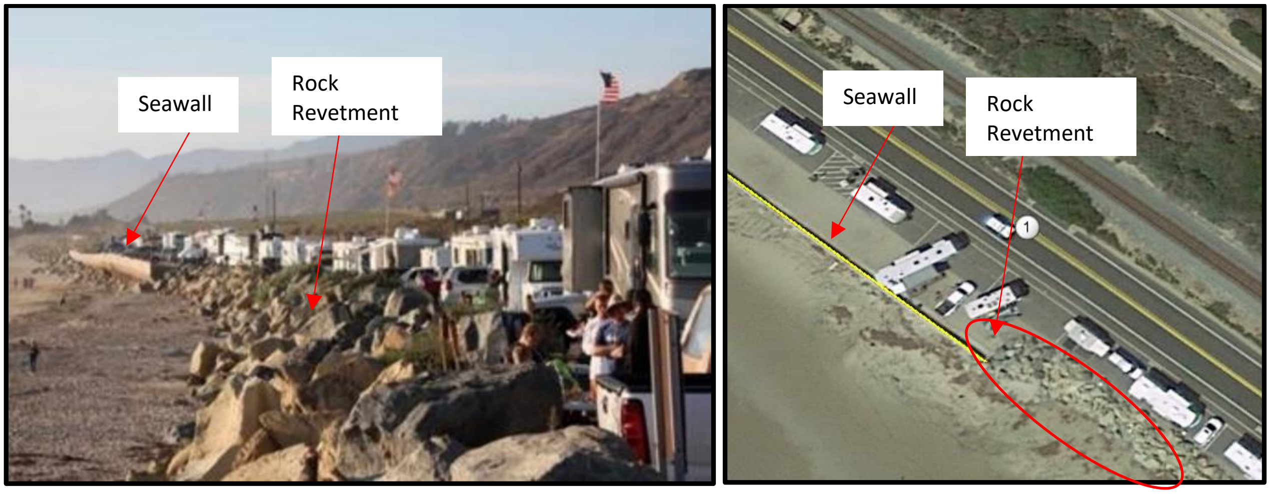
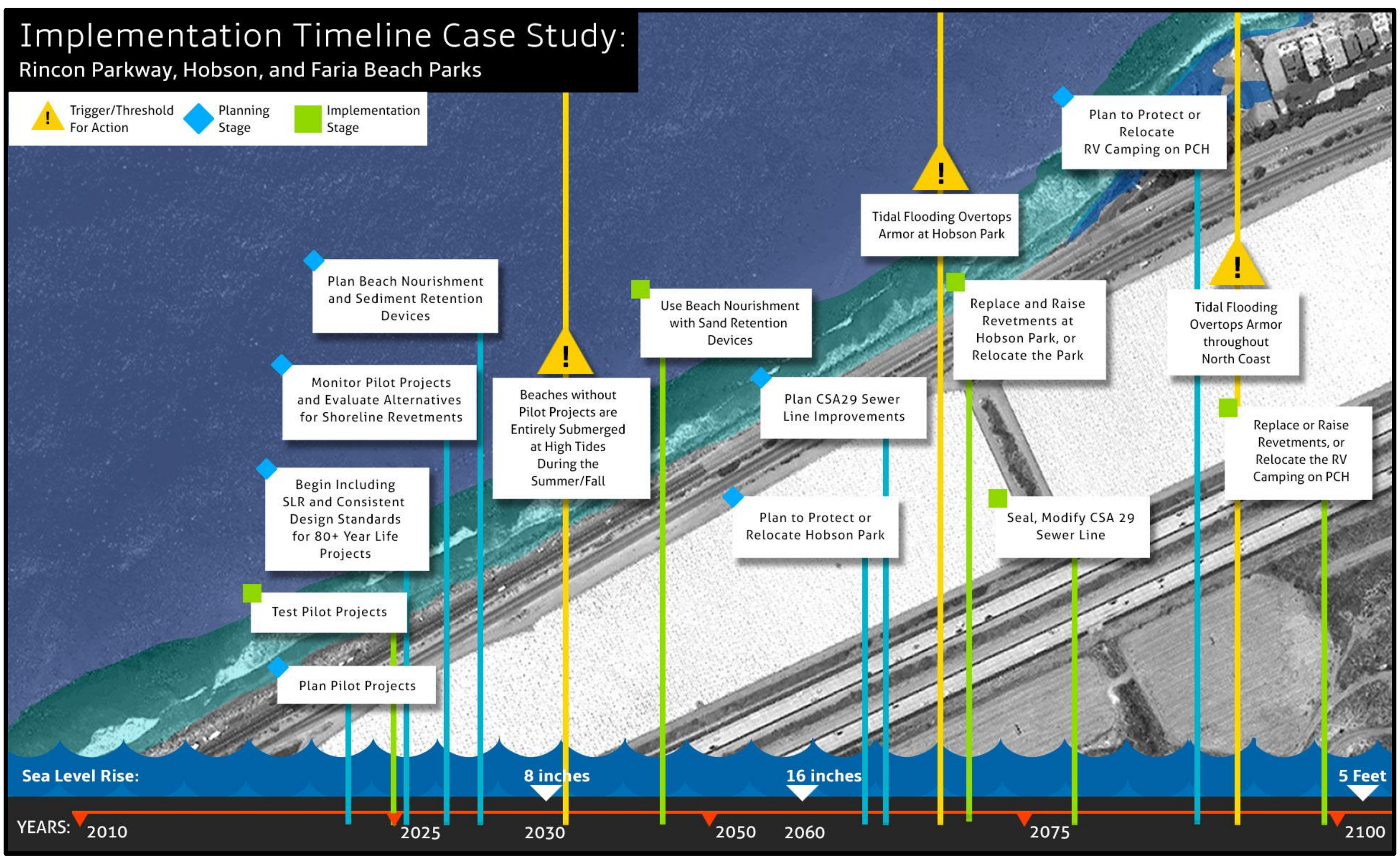


Figure 3-10: Hypothetical Adaptation Pathway Case Study for Rincon Parkway, Hobson and Faria Parks Improvements. Note that the yellow-colored line representing a "Trigger for Action" would initiate the next phase of adaptation measures.



APPENDIX A. NATURAL RESOURCES ADAPTATION MATRIX

This Section includes a data table developed by the Natural Resources Working Group. It summarizes identified vulnerabilities and the potential adaptation strategies that could be employed to minimize sea level rise impacts on focal species and habitats. Many of these strategies were integrated into Sections 3.1 and 3.2 of this Report.

At the beginning of VC Resilient, The County formed a Natural Resources Working Group with 35 participants to help evaluate and assess the vulnerability of selected coastal species and habitats. This group consisted of federal, state, and local biologists, botanists, and ecologists familiar with the County's flora and fauna and who are subject-matter experts in the natural ecosystems of Ventura County. Participants were directly involved with the Vulnerability Assessment and helped with the identification of adaptation strategies.

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Summary of Potential Adaptation Strategies for Natural Resources that are Vulnerable to Sea Level Rise				
Habitat Type	**Focal Species**	**Identified Vulnerability**	**Causes**	**Potential Adaptation Strategies**
All four evaluated (beaches, dunes, estuaries, fresh water)	All (19)	Loss of shoreline habitats (includes USFWS Western Snowy Plover critical habitat)	▪ Erosion and tidal inundation ▪ Lack of areas for habitat migration ▪ Decline of sediment transport (includes dams and coastal armoring)	▪ Species monitoring for sea level rise (SLR) changes ▪ Increase sediment supply: Beach nourishment, minimize shoreline armoring, removal of dams/dikes/levee/channelized stream areas ▪ Protect shoreline: Off-shore living reefs, living seawalls, dune restoration/creation, tidal benches, marsh sills, horizontal levees ▪ Voluntary managed retreat: Allow for migration of habitats using fee-acquisition, easements, downzoning, etc. in appropriate areas
All four evaluated	All (19)	Degradation of niche habitat from SLR primary effects (inundation, flooding, erosion) and secondary effects (habitat fragmentation; increased susceptibility to invasive species; increased human activity and use on remaining habitats, pollution, temperature changes, etc.)	▪ Erosion ▪ Tidal inundation ▪ Storm flooding ▪ Decline of sediment transport ▪ Increase wave intensity	▪ Multi-jurisdictional (if needed) habitat management plans that include adaptive management strategies and monitoring for projected SLR impacts ▪ Flooding: Setbacks from adjacent agriculture operations and development to prevent pollution runoff ▪ Inundation/Flooding: Restrictions on herbicide/pesticide/fertilizer use on agricultural fields adjacent to salt marsh and tributaries to estuaries at projected SLR heights ▪ Inundation/Flooding: Provide adequate buffers around estuaries and potential migration areas ▪ Sediment Transport: Increase sediment supply (see above); elevate wetlands; cobble berm/dune restoration
			▪ Habitat fragmentation	▪ Require habitat connectivity/wildlife corridors to nearby larger native habitats during review of new development proposals ▪ Reduced development potential allowed by zoning on adjacent parcels to at-risk habitats ▪ Development setbacks to wetland and water features (buffer zones) ▪ Habitat restoration
			▪ Invasive species spread by development, maintenance activities, intentional release, recreational activities, and natural forces ▪ Predation and competition from invasive species	▪ Invasive species removal/control in area management plans and adjacent development proposals ▪ Develop breeding programs for at risk species (e.g., Southwestern pond turtles)
			▪ Lack of refuge habitats during flood events	▪ Habitat restoration to create refugia habitat during major flood events (See Sediment Transport, above) (areas containing slow-moving water with ample adjacent quality terrestrial habitats, access to habitat with higher elevations) ▪ Identify sensitive estuarine habitat areas in vector control plans
			Pollution and temperature changes cause: ▪ Non-point source runoff from adjacent land uses ▪ Removal of vegetation ▪ Drought	▪ Employ adequate setbacks for all land uses ▪ Habitat restoration ▪ Identify sensitive estuarine habitat areas in vector control plans ▪ Strategic water releases for wildlife from reservoirs
			Increased development/use pressures on remaining habitat cause: ▪ Disruption of dune formations from grooming and recreation ▪ Noise/lighting from nearby development and recreation ▪ Disturbance/mortality from vehicles, aircraft, dogs, people ▪ Predation pressures associated with human development ▪ Loss of beach and dunes from coastal armoring	▪ Dune Disruption: Dune restoration/establishment; County/multi-jurisdictional sand management plan; beach grooming and sand moving protocols (e.g. Grunion grooming protocols) ▪ Lighting and Noise: apply restrictions on beach front properties and on temporary events ▪ Disturbance/Mortality: Education to beachgoers for sensitive grunion and plover species (signage, pamphlets, etc.) restriction of special events on certain beaches at certain times of year; Design beach infrastructure to funnel people away from sensitive areas (walkways, fencing, signage/kiosks) ▪ Predation Pressure: Provide adequate buffers around estuaries and potential migration areas from future development

Habitat Type	Focal Species	Identified Vulnerability	Causes	Potential Adaptation Strategies
All four evaluated	All (19)	Disruption of species pollination/breeding and dispersal mechanisms	Coastal storm and tidal inundation events (wind, flooding) cause: ▪ Artificial breaches, freshwater releases and extractions, groundwater extraction, vector control, etc. ▪ Salinity changes in upper estuaries and coastal wetlands ▪ Flooding or destruction of breeding areas	▪ Multi-jurisdictional habitat management plans (see Degradation of Niche Habitat, above) ▪ Estuarine/Freshwater Salinity: Develop monitoring plans that track populations and changes in salinity ▪ Flooding/Inundation: Reduce wave energy on beaches (off-shore reefs, breakwaters)
All four evaluated	Western Snowy Plover California Grunion Belding's Savannah Sparrow	Reduced primary food sources (plankton, invertebrates, beach wrack, etc.)	▪ Beach grooming ▪ Warming water conditions and loss of kelp forests ▪ Pollution/algae blooms caused by stormwater runoff or flooding	▪ Explore feasibility of regulatory triggers or disincentives for chemical use on properties subject to flooding or tidal inundation ▪ Setbacks from creeks/rivers for new development ▪ Adopt beach grooming and sand moving protocols
Beach / Dune / Estuarine	California Grunion Tidewater Goby	Potential increase in unsuitable spawning substrates	▪ Storm flooding and tidal inundation ▪ Sand movement activities ▪ Changes in salinity during spawning events	▪ Determine factors influencing grain size and beach shape/salinity to develop strategies ▪ Implement grunion grooming and sand moving protocols ▪ Estuarine management plan (See Degradation of Niche Habitat, above)
Dune Estuarine Freshwater	All Seven Plant Species	Loss of insect pollinators	▪ Increased fragmentation of remaining habitats that may influence plant pollinators	▪ Within resource management plans account for fragmentation effects ▪ Require habitat connectivity with development proposals that includes projected SLR effects ▪ Provide education of native plants for pollinators in landscaping
			▪ Herbicide and pesticide drift from adjacent development and uses	▪ Adequate setbacks of habitats from agricultural fields and development
Freshwater / Upland Habitat	Monarch Overwintering Sites	Changes in microsite roost habitat	Tidal inundation and storm flooding may: ▪ Kill nectar plants or roost/shelter trees; create pooling water under roost trees; or increase saline conditions in nearby freshwater sources. ▪ Increase pests and diseases due to stressed biological conditions	▪ Restore nearby/adjacent habitat to migrate roost areas from areas of potential tidal inundation. Monitor roost populations ▪ Establishment of new roost/shelter trees and restoration of roost areas ▪ Monitor for signs of pests and disease to curtail invasions and disease outbreaks asap – remove infected plants/trees
USFWS Ventura Marsh-Milk Vetch Critical Habitat	Ventura Marsh-Milk Vetch Habitat	Unknown flood effects Herbicide runoff	▪ Storm flooding	▪ Monitor populations

APPENDIX B. ECONOMIC ANALYSIS of ADAPTATION STRATEGY CASE STUDIES

As part of the adaptation planning process, following a relatively comprehensive identification of potentially suitable adaptation strategies (See Chapter 3), an initial economic evaluation of four prioritized adaptation strategies was conducted to correspond with the adaptation pathway case study examples presented in Section 3.3. The intent of this analysis is to provide further information to decision makers to help identify appropriate next steps for sea level rise adaptation. While these strategies would improve County-owned facilities and public assets that are among the first coastal areas predicted to be exposed to sea level rise, all of these strategies would either also protect adjacent private lands or could also be used on private lands if they are initially successful.

In this section the following adaptation strategies and their respective cost estimates were explored:

- The construction and maintenance of low hummocky native vegetated sand dunes along Hollywood and Silverstrand beaches.
- Improvements to the stormwater system at the Silverstrand Beach neighborhood.
- Coastal armor design changes associated with replacement of existing rock revetments with a vertical seawall along the Hobson/Rincon Parkway/Faria Beach Parks.
- Sediment retention on narrow beaches along Hobson/Rincon Parkway/Faria Beach Parks with ephemeral cobble-based groins.

This economic analysis generally compares the estimated costs of employing the adaptation strategies listed above, with the estimated values of the resources that would be protected. The value of vulnerable property, residential dwellings, agriculture, coastal access (e.g. tourism), and key types of infrastructure are summarized in Section 5.2 of the Vulnerability Assessment. In both this report and the Vulnerability Assessment, cost estimates are converted into 2018-dollar values. The estimated costs for the adaptation strategies are derived from similar projects within Ventura and nearby counties.

B.1 Native Dune Construction

Sand dunes have been proven around the world to provide natural protection to coastal communities during large storm events. Dunes in Ventura County could take many forms. The native dune form is a wider low-lying dune field which has shown to reduce coastal wave flooding. Non-native vegetated dunes can be very high and restrict views, limit stormwater conveyance, and increase the effort required to access the beach. Photo B-1 shows a native vegetation restored dune at Surfer's Point in the City of Ventura during the ~25-year wave event which occurred on December 11, 2015.

Photo B-1. Restored native vegetation dune at Surfer's Point taken during a major coastal wave flood event. Notice that in the foreground and background the dunes limit coastal wave flooding, while in the unvegetated kiteboarding landing area, waves reach all the way back to the bike path.

In concept a dune restoration and maintenance program could enhance protection of land uses and development for many decades, even in the face of sea level rise (Figure B-1).

This economic analysis examined the costs and benefits of a native vegetation dune restoration focused on two vulnerable neighborhoods – Hollywood Beach and Silverstrand. The comparisons show the potential economic impact due to a reduction in the vulnerability of residential land uses with and without coastal storm protection from dunes. While the suitability of dune restoration along the entire expanse of Hollywood and Silverstrand Beaches remains to be decided, and public outreach and support from decision-makers would be needed, there was only incremental additional effort required to include both areas in the analysis. Given the recreational popularity of Silverstrand Beach, seasonal sand berms could provide an alternative to natural dunes until the viability of natural dunes are tested at nearby locations such as Hollywood Beach.

The analysis of this living shoreline dune adaptation approach utilized coastal hazard modeling data developed as part of the Coastal Resilience Ventura project and the Fair Market Value adjusted assessor parcels (used in the County's vulnerability assessment).[47] Hazard modeling that considered a constructed and maintained dune show that with periodic maintenance the dunes could provide 100% protection from projected storm erosion and coastal flooding with 5 feet of sea level rise and a 1% annual chance storm. Given the abundance of sediment on the Central Coast, and sediment management controls associated

[47] ESA PWA; Coastal Resilience Ventura – Technical Report for Coastal Hazards Mapping. Prepared for the Nature Conservancy, July 2013.

with navigational dredging of Channel Islands Harbor near both beaches, this adaptation approach could likely be viable to protect these neighborhoods from coastal erosion and wave flooding damages for up to 5 feet of sea level rise.

Some flooding could still occur during rain events without changes in stormwater conveyance systems which presently drain along roadways onto the beach. With dunes in place, stormwater may not be able to gravity drain and so, it is likely that additional stormwater retrofits and increased pumping capacity may be required.

Costs

To bracket the uncertainty surrounding dune construction costs, this study obtained multiple cost estimates for both dune construction and dune maintenance. The low-end construction estimates were provided by Karina Johnston of the Bay Foundation based on the pilot dune experiment in Santa Monica. The project was initiated in December 2016 and uses natural processes and native vegetation and sand sources to allow beach wrack and natural windblown sediment processes to occur in a fenced off area[48]. Her cost estimates assume a cost of $300 per linear foot, assuming a 100-foot dune width[49]. The high-end cost estimates for dune construction ($1,200 per linear foot) are taken from a report by Everest Consulting provided to the City of Oxnard as part of their LCP Update. These costs are also comparable to those provided by the City of Imperial Beach for a similar project ($1,000 per linear foot).[50] The low-end construction and maintenance costs are significantly lower than those provided by Everest and Imperial Beach in part because they assume, natural wind-blown sand, volunteer labor and non-profit rates.[51] The high-end maintenance costs are taken from adaptation costs provided to the City of Morro Bay, which estimate that 50% of the dunes must be reconstructed every five years.[52] The costs per linear foot were multiplied to the 7,000 and 4,500 foot lengths that approximate the lengths of Hollywood and Silverstrand reaches, respectively.

Benefits

The analysis of benefits summarized the value of property damages that would otherwise occur without adaptation and any changes to recreational benefits from creating dunes. The key benefit of the constructed and maintained sand dune is the avoided damages from erosion and flooding during large storm wave events.

Recreational use at both Silverstrand and Hollywood beaches differ in types and amount of use. Silverstrand has much higher recreational use of both beach and surfers and thus higher benefits despite being a smaller area. As reported in the Vulnerability Assessment, Silverstrand generates $15.5 million in direct recreation spending, and $19.8 million in non-market benefits per year from its estimated 410,000 in annual attendance; surfing contributes almost half, $8.8 million, of the non-market benefits. Hollywood

[48] Also see: https://www.santamonicabay.org/explore/beaches-dunes-bluffs/beach-restoration/santa-monica-beach-restoration-pilot/

[49] Karina Johnston; Science Director for the Bay Foundation; personal communication on December 20, 2018.

[50] Revell, D. L., King, P., Calil J., Giliam, J.; City of Imperial Beach Sea Level Rise Assessment; September 2016; available at https://goo.gl/xiGzTn

[51] Karina Johnston; Science Director for the Bay Foundation; personal communication on December 20, 2018.

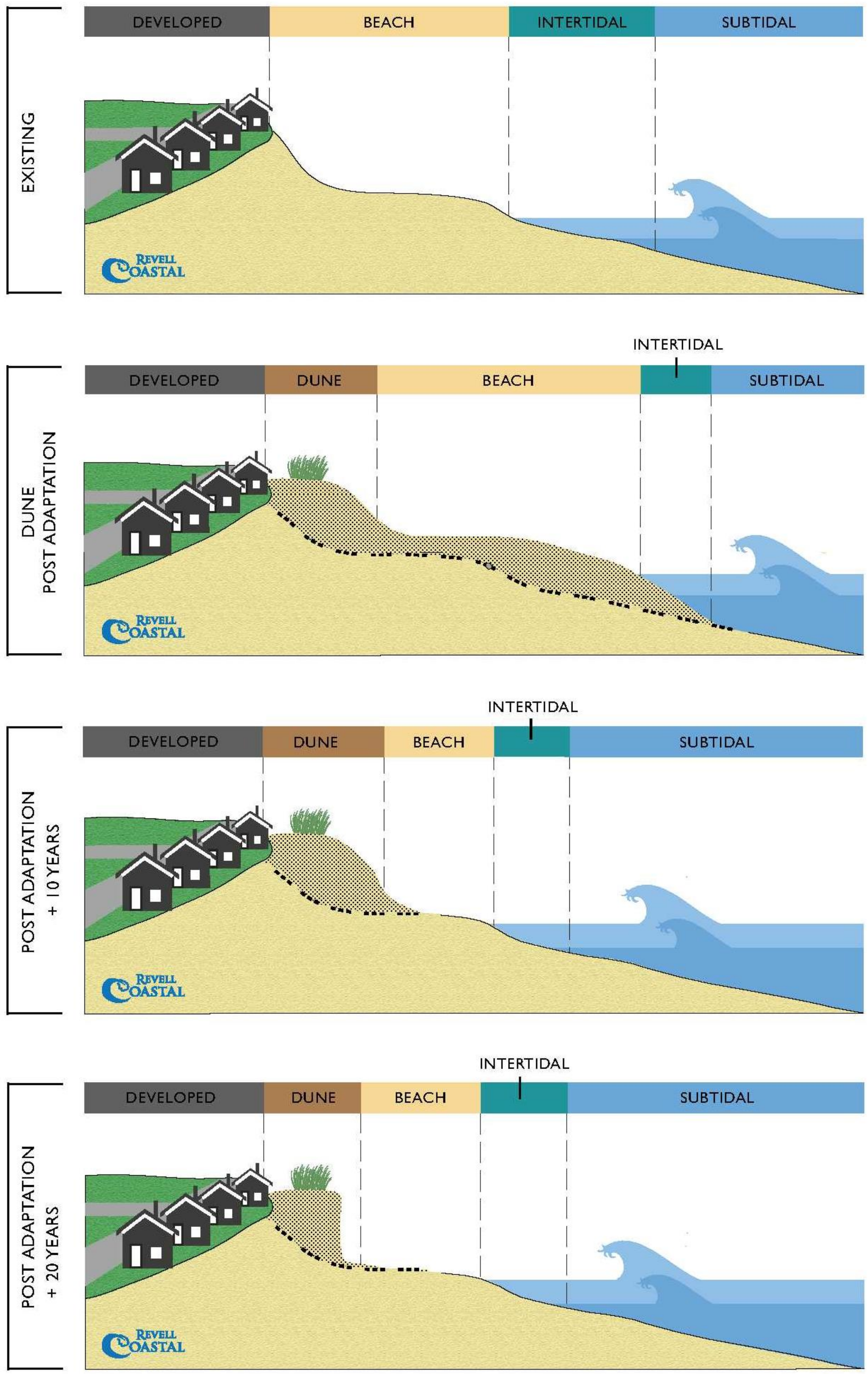
[52] City of Morro Bay; Sea Level Rise Adaptation Strategy Report; January 2018.

Beach has a smaller attendance per year (50,000 visitors) and generated $2 million in non-market benefits (just under $500 million for surfing) and $1.2 million in direct spending.

In both areas, however, there is adequate beach width (greater than 250 feet) to sustain current levels of beach recreation and there would not be any impact to popular surf breaks from having the dunes on the beach. The sand dunes, built along the back of the beach, would reduce the usable dry sand beach width by approximately 75 feet. However, the space available for visitors to put down their towels and recreate is more than adequate and the dunes may also give beach visitors an additional amenity of separation from the residential area behind the beach. Recreational economic models have shown that if the beach is wider than ~250 ft, there is a decline in recreational value of having an even wider beach, since people tend to avoid the long walk over the sand, especially when it is hot. Consequently, this analysis assumes that the recreational value of each of these beaches does not change significantly with dune construction.

The analysis did not include any consideration of habitat enhancement benefits such as: (1) water filtration; (2) the processing of organic matter and recycling of nutrients within the beach and nearby ecosystems; (3) invertebrate infaunal and kelp wrack community that provides food for fish and birds; (4) critical spawning habitat for the California grunion and other beach spawning species, and; (5) nesting, roosting, and foraging habitat for sea and shorebirds. The value of these benefits would likely be enhanced with dunes.

Figure B-1. Conceptual evolution of a native vegetation dune restoration. Maintenance of the dunes may be required following major coastal erosion events, as shown in the bottom panel.



Hollywood Beach

Table B-1 (below) maps the differences and provides a summary of the estimated vulnerability of Hollywood Beach parcels and structures to storm erosion and coastal flooding. Figure B-2 compares vulnerabilities with and without the protection of dunes to show the projected benefits of dune protection. This analysis is based on nature-based adaptation modeling that was included in the Coastal Resilience Model.

Figure B-2. Potential vulnerabilities to land use and structures between a do-nothing approach and a restore-native-dunes approach at Hollywood Beach (Source: Coastal Resilience Model).

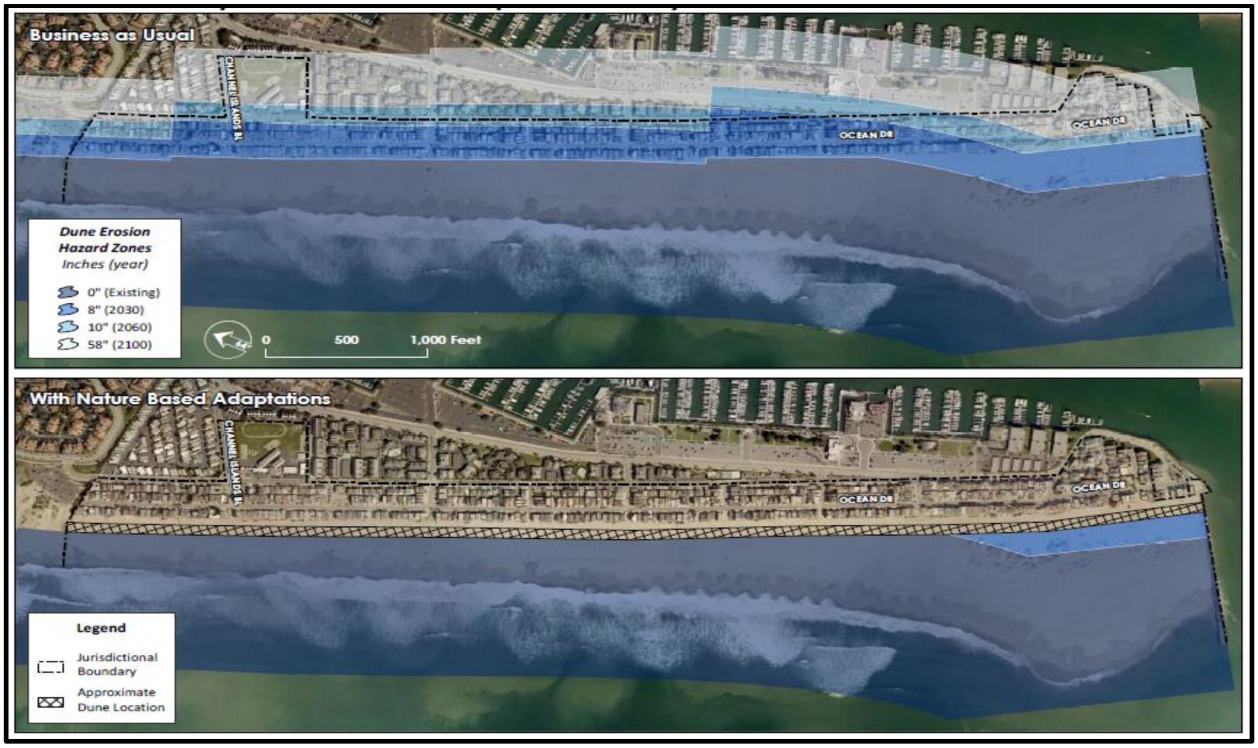


Table B-1. Estimated Benefits from Dunes at Hollywood Beach.

Sea Level Rise	Losses w/o Dunes	Losses w/ Dunes	Total Benefits (Undiscounted)	Present Value of Benefits (@3%)
Storm Erosion				
8 Inches	$613,000,000	$0	$74,000,000	$63,000,000
16 Inches	$705,000,000	$0	$272,000,000	$155,000,000
58 Inches	$768,000,000	$0	$567,000,000	$206,000,000
Coastal Flooding				
8 Inches	$110,000,000	$0	$13,000,000	$11,000,000
16 Inches	$126,000,000	$0	$49,000,000	$28,000,000
58 Inches	$196,000,000	$0	$113,000,000	$39,000,000

As indicated in Table 1 above, sand dunes could prevent $613 million to $768 million (with 8 and 58 inches of sea level rise, respectively) of property losses due to storm erosion during a 1% (100-year storm) event and $110 million to $196 million (with 8 and 58 inches of sea level rise, respectively) in property damages and losses due to coastal wave flooding during such an event.[53] When one accounts for the probability of a 1% annual chance storm (i.e. 100-year storm) event over the time period, the expected benefits will be significantly lower. Table 1 provides the *expected potential* property damages and losses from a 1% annual chance storm event over the time horizon. If we assume future benefits are no less valuable than present benefit, (equivalent to a 0% discount rate) then the dunes provide an estimated savings by avoiding $567 million losses in erosion and $113 million in flooding damages with 58 inches of sea level rise. If, future benefits are discounted at 3%, then the benefits are significantly smaller— $206 million and $39 million, respectively.

Table B-2 (below) estimates the cost of constructing and maintaining the sand dunes along the approximately 7,000-foot-long Hollywood beach. While the estimates for dune construction vary considerably – between $300 and $1,200 per linear foot – those of dune maintenance differ by larger amounts. The differences in maintenance costs are due to the lack of comparable successful case studies. The metrics used by the City of Morro Bay put 20-year dune maintenance at twice the cost of the construction itself. Those used by Johnston are significantly lower.[54] Given the prevailing westerly onshore wind direction and relatively stable beaches due to the sand traps and harbor jetties associated with Channel Islands Harbor, it could be anticipated that recovery of the beach and dune system could occur naturally and reduce these maintenance costs to the lower end of the estimate range.

Table B-2. Estimated Cost of Dunes at Hollywood Beach.

	Estimate (High)	Estimate (Low)	Present Value of Estimate (High)	Present Value of Estimate (Low)
Dune Construction	$8,600,000	$2,100,000		
20-yr Maintenance	$17,100,000	$42,000	$13,600,000	$33,000

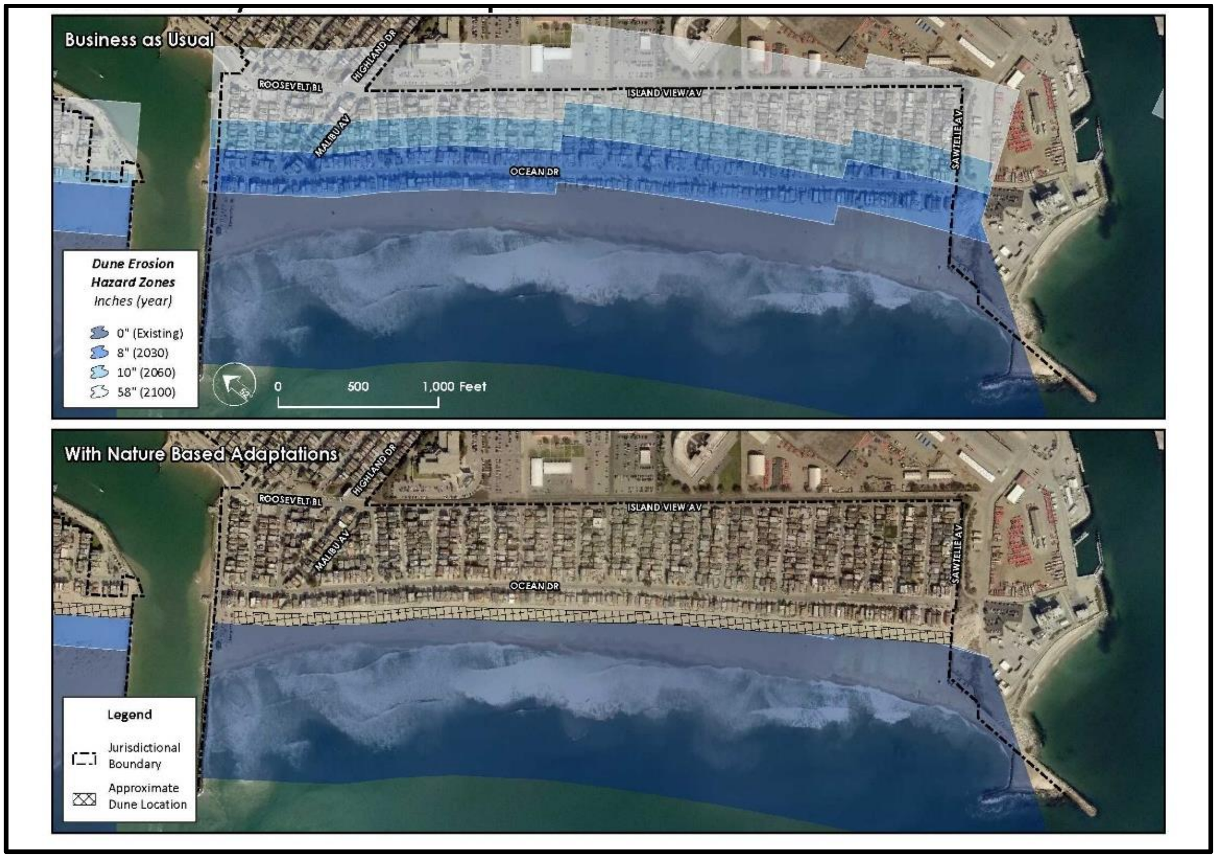
Silverstrand Beach

Figure B-3, Tables B-3 and B-4 provide the results of the same analysis for Silverstrand Beach. As in the case of Hollywood Beach, dune construction is assumed to protect against all storm erosion and coastal flooding in the case of a 100-year storm event. Consequently, this adaptation strategy is estimated to prevent $368 million to $712 million (with 8 and 58 inches of sea level rise, respectively) in property losses to storm erosion and $41 million to $207 million (with 8 and 58 inches of sea level rise, respectively) in property losses and damages to coastal flooding. As with Hollywood Beach above, the expected benefits and the present value of these benefits is lower: $436 million in erosion losses and $70 million in coastal

[53] Consistent with the method used for the Vulnerability Assessment, erosion losses are assumed to be 100% of impacted land area and structures. Flooding damages are estimated using Army Corps of Engineer depth damage curve estimates.
[54] City of Morro Bay; Sea Level Rise Adaptation Strategy Report; January 2018.

flooding damages, or $144 million in erosion losses and $18 million in coastal flooding damages if a 3% discount rate is applied.

Figure B-3. Potential vulnerabilities to land use and structures between a "wait and see" approach and a restore native dunes approach at Silverstrand Beach.



However, unlike Hollywood Beach, the Silverstrand neighborhood is much more exposed to future tidal inundation and potential groundwater daylighting than Hollywood Beach.[55] Consequently, while sand dunes significantly reduce the exposure of Silverstrand property to tidal inundation (~95%), there is likely still $37 million in property value exposed to inundation with 58 inches in sea level rise that may have to be addressed with increased pumping capacity (see Stormwater Upgrade Section below).

[55] "Groundwater daylighting" is a term used to describe a physical process during which previously dry areas with high ground-water become wet with ponded water. During high tides and sea level rise, the high groundwater "daylights" in low lying areas as seawater and groundwater percolate above the ground and appear as ponds.

Table B-3. Estimated Benefits from Dunes at Silverstrand Beach.

Sea Level Rise	Losses w/o Dunes	Losses w/ Dunes	Total Benefits	Present Value of Benefits
Storm Erosion				
8 Inches	$368,000,000	$0	$44,000,000	$38,000,000
16 Inches	$551,000,000	$0	$183,000,000	$101,000,000
58 Inches	$712,000,000	$0	$436,000,000	$144,000,000
Coastal Flooding				
8 Inches	$41,000,000	$0	$5,000,000	$4,000,000
16 Inches	$48,000,000	$0	$18,000,000	$10,000,000
58 Inches	$207,000,000	$0	$70,000,000	$18,000,000

Because the alongshore length of beach at Silverstrand is shorter than that at Hollywood, the costs of constructing and maintaining the dune are therefore reduced.

Table B-4. Estimated Cost of Dunes at Silverstrand Beach.

	Estimate (High)	Estimate (Low)	3% PDV Estimate (High)	3% PDV Estimate (Low)
Dune Construction	$5,500,000	$1,400,000		
20-yr Maintenance	$11,000,000	$27,000	$8,700,000	$21,000

Summary

At both Hollywood and Silverstrand beaches, the benefits of dune construction, in terms of storm damage prevention, are significantly higher than the costs, indicating that dune construction is worth serious attention as an adaptation alternative. There are likely to be several ways to implement such an adaptation strategy and there would also be a necessity to engage the communities and regulatory agencies around visual, aesthetic, access, and habitat issues that may arise in the future.

B.2 Stormwater System Improvements

A couple of challenges with dune restoration is that it may inhibit stormwater conveyance during rainfall events, and that it does not stop tidal inundation that can percolate through sandy soils in low-lying areas (groundwater daylighting) or flow from the Channel Islands Harbor and storm drain network. One solution to address these types of flooding is to install pumps to remove this water during extreme high tides and/or rainfall events. For the Silverstrand neighborhood in particular, several areas appear vulnerable in the future (Figure B-4).

Figure B-4. Potential locations of groundwater daylighting and stormwater induced flooding with 58" of sea level rise.

The Silverstrand Pump Deficiency Study provided low- and high-end cost estimates for the upgrading of all stormwater pump stations at $900,000 and $2,400,000, respectively (Table B-5).[56] By way of comparison, Everest estimated the cost of a similar stormwater system upgrade for Oxnard Shores to cost between $800,000 and $1.2 million.[57]

[56] Watershed Protection District, Silverstrand Pump Deficiency Study, May 2014. Subsequent communications with the Watershed Protection District estimated the costs to be $150,000 per pump, and there are four pumps.
[57] See Oxnard LCP Cost Estimate excel file. Sent from Rincon December 6, 2018.

Table B-5. Estimated Costs of Upgrading Stormwater Pump Stations in Silverstrand.

	Estimate (High)	Estimate (Low)	Tidal Exposure w/o Dunes	Tidal Exposure w/ Dunes or Berms
Stormwater Upgrades	$2,400,000	$900,000	$603,000,000	$37,000,000

Additional engineering designs would be required to upgrade the stormwater system to address sea level rise, and particularly to reduce the exposure of the stormwater outfalls to coastal erosion or wave exposure. The most effective ways to collect and convey the stormwater also need to be more thoroughly addressed, which are beyond the scope of this limited investigation; however, the projected benefits of upgrading the system to reduce tidal exposure far outweigh the projected costs.

B.3 Replacement of the Revetment with a Seawall at Hobson and Faria County Parks, and Along the Rincon Parkway

One of the impacts of a revetment is the placement loss or burial of portions of the beach under the footprint of the armoring. In narrow beach areas, this placement loss can significantly limit available recreational beach and lateral beach access. This analysis evaluated the potential benefits to recreational use by replacing the existing revetments along the Rincon Parkway, and at Hobson and Faria County Beach Parks with a vertical seawall which has a much smaller footprint (Figure B-5). Conceptually over time as sea level rises, the beach is still lost, but the additional beach for a couple decades may provide some additional recreational revenues that may offset the cost. Any adaptation strategies involving the Rincon Parkway will require coordination with Caltrans, as they own the revetments along Old Coast Highway.[58]

Table B-6 (below) provides the high and low estimated costs for the construction of a 10,300-foot seawall along Hobson/Rincon/Faria coastline. Everest Consulting estimated the cost for the construction of a seawall at $5,300 per linear foot.[59] and the high and low-end estimates represent 120% and 80% of this figure. Caltrans similarly estimates the cost of construction to be $5,225 per linear foot, essentially the same arrived at by Everest.[60] The cost of maintenance was taken from an estimate provided at the City of Imperial Beach which placed it at 2% of the original construction cost every 10 years.[61] The Imperial Beach study also provided the high-end cost estimate for removing the revetment ($1,000 per linear foot), while the low-end estimate ($600 per linear foot) was taken from the Hobson/Rincon/Faria Caltrans estimates. In addition, the various structures along the Rincon Parkway are in a wide variety of conditions and it is also likely that the existing revetments will be needed to be rebuilt and or augmented over this next 20-year cycle (Photo B-2).

[58] The County and Caltrans have a longstanding Memorandum of Understanding that allows the County to maintain and operate public recreational uses along the Rincon Parkway.

[59] See Oxnard LCP Cost Estimate excel file. Sent from Rincon December 6, 2018.

[60] Wilford, Melton; Caltrans Senior Transportation Planner; personal communication on January 18, 2019.

[61] Revell, D. L., King, P., Calil J., Giliam, J.; City of Imperial Beach Sea Level Rise Assessment; September 2016; Available at https://goo.gl/xiGzTn

Figure B-5. Conceptual illustration of how removal of the revetment and construction of a seawall creates more usable recreational beach and lateral access.

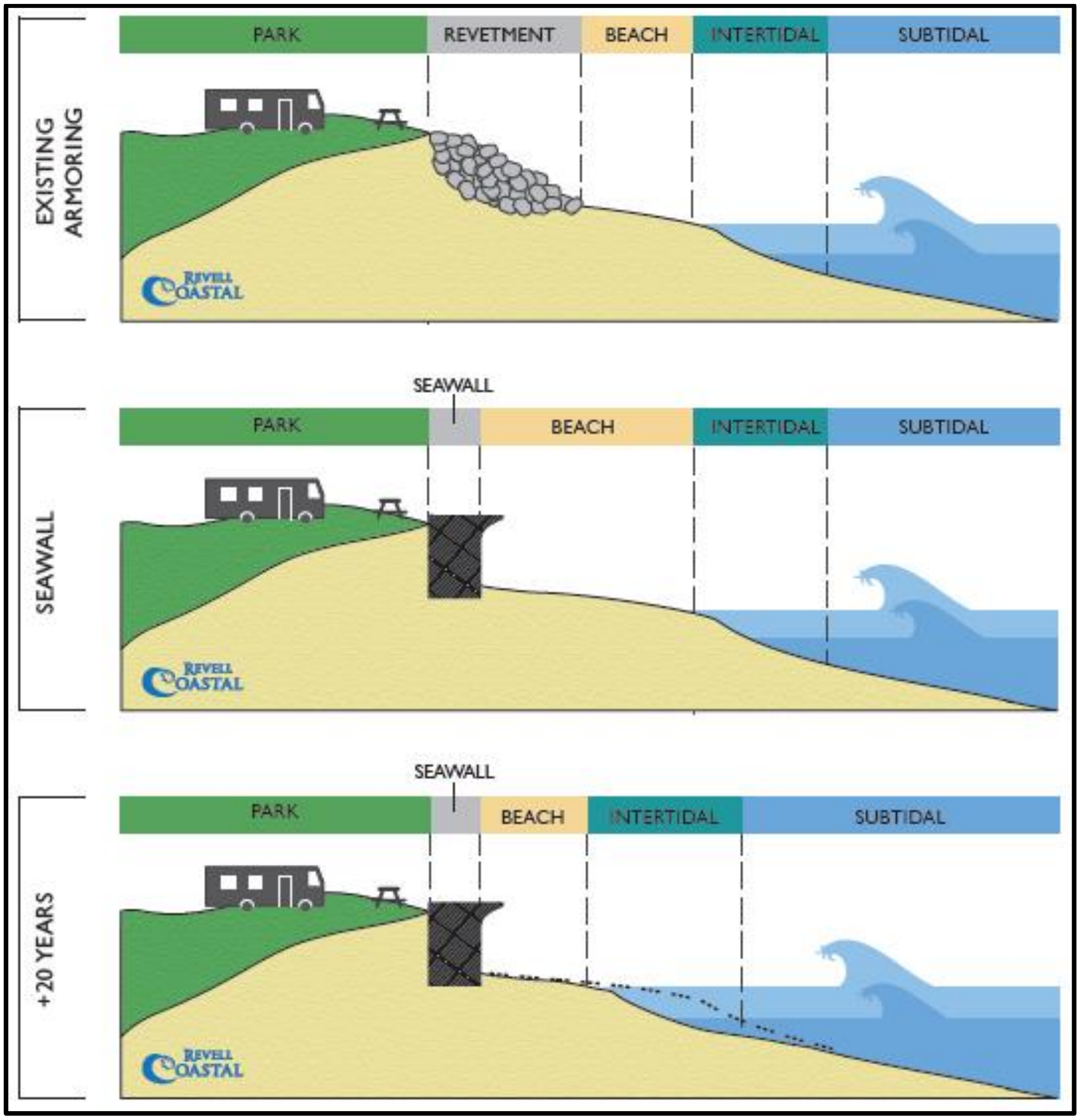
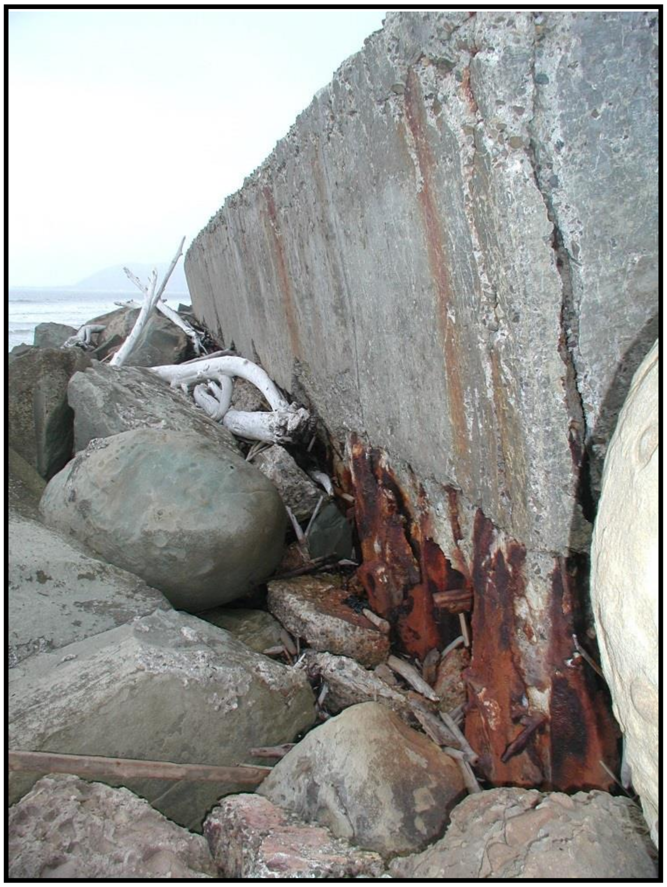


Photo B-2. Example of existing conditions of coastal armor along the Rincon Parkway.



Using data provided by Everest and Caltrans, we were also able to estimate the potential cost of constructing revetments and maintaining them for 20 years. While Everest estimates this cost to be $5,300 per linear foot, Caltrans provides a lower estimate at $2,500 per linear foot, for a total of $54.6 million to $25.8 million.[62] Caltrans also estimates 20-year maintenance costs for revetments to be between $720 and $480 per linear foot, for a total of $5.9 million to $3.9 million in present discount value over the subsequent 20-year period.

While the use of maintenance costs from Imperial Beach may not be the most applicable because there are different geomorphic settings and wave exposure (Imperial Beach has wider beaches and deeper sand on the beaches), however additional engineering analysis would be required to determine actual maintenance costs. Conceptually, following initial construction, the wider fronting beach would have lower maintenance costs as wave energy is dissipated more on the beach, but as sea level rises, and the beach narrows maintenance costs would be expected to increase.

Recreational Benefits of a Seawall Increasing Beach Width

This analysis estimated the additional recreational benefits associated with a wider beach if the revetment along this corridor were to be replaced with a seawall, which would add an estimated 20 feet of additional beach width to a very narrow beach. As indicated in Table B-6, the increase in beach width along this corridor, from a current width of approximately 20 feet, to 40 feet, will significantly enhance recreational value. To estimate the increase in recreational value, this analysis employed the CSBAT model, which Dr. King developed for the Army Corps of Engineers and the State of California.[63] The analysis indicates that the recreational benefits over a 20-year period would be $36.5 million; or $27.7 applying a discount rate.

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[62] See Oxnard LCP Cost Estimate excel file. Sent from Rincon December 6, 2018, and personal communication with Melton Wilford, December 28, 2018.

[63] California Department of Boating and Waterways and San Francisco State University; "The Economic Costs of Sea Level Rise to California Beach Communities".

Table B-6. Estimated Costs of Construction and Maintenance of 10,300 ft-long Seawall.

	Estimate (High)	Estimate (Low)	Present Value of Estimate (High)	Present Value of Estimate (Low)	High Metric	Low Metric
Seawall Construction	$65,500,000	$43,700,000			$6,360 per ft.	$4,240 per ft.
20-yr Seawall Maintenance	$2,620,000	$1,748,000	$2,100,000	$1,400,000	40% of construction cost	40% of construction cost
Revetment removal	$10,300,000	$6,180,000			$1,000 per ft.	$600 per ft.
Total	**$78,420,000**	**$51,628,000**	**$77,900,000**	**$51,280,000**		
Revetment Construction	$54,600,000	$25,800,000			$5,300 per ft.	$2,500 per ft.
20-yr Revetment Maintenance	$7,400,000	$4,900,000	$5,900,000	$3,900,000	$720 per ft.	$480 per ft.
Total	$62,000,000	$30,700,000	$56,100,000	$26,800,000		

For a 30-year period, the benefits increase to $54.5 and $36.6 million (Table B-7). These recreational benefits are based on an assumption that the increase in beach width remain for the stated time periods, however, in this setting, without additional sediment or sand retention, in the face of sea level rise, this beach would likely narrow.

Table B-7. Estimated Recreational Benefits of a Seawall (*PV = Present Value).*

Scenario	Recreational Benefit per Year	Recreation: 20-Year Benefits	Recreation: 20 yr. PV Benefits @ 3%	Recreation: 30-Year Benefits	Recreation: 30 yr. PV Benefits @ 3%
Current Conditions	**$ 7,250,000**	**$145,000,000**	**$110,925,000**	**$217,500,000**	**$146,366,296**
Reduced Footprint	$9,062,500	$181,250,000	138,656,250	$271,875,000	$182,957,870
Additional Recreational Value	**$1,812,500**	**$36,250,000**	**$27,731,250**	**$54,375,000**	**$36,591,574**

Summary

Given the costs from Table B-6 above, the costs of revetment removal, seawall construction and maintenance would be roughly in-line with the benefits over a 30-year period, but costs would exceed recreational benefits over a twenty-year period. If Ventura County is interested in pursuing this option, a more careful analysis that considers existing armor conditions, access, beach stability with and without sand retention, is warranted. These estimates assume that attendance will stay the same (290,000 per year). If removing the revetment significantly increased visitation, or additional camping was created, then the project might be justified, or if one could quantify other benefits (e.g., other ecological benefits). Given the lack of an engineering assessment of the existing conditions (a recommended next step), replacement cost of a new revetment should also be considered and could be between $54.6 million and $25.8 million although total removal of the existing revetment would not be required as the existing revetment could be repurposed. Another consideration not evaluated directly, would be the use of sand retention structures along the Rincon Parkway, such as groins or cobble groins (Figure B-6) which could further increase the recreational beach width, potentially prolong the life of the beach and reduce the armoring maintenance costs, none of which was included in this initial analysis.

B.4 Sediment Retention through Cobble-Based Groins at Hobson and Faria County Parks, and the Rincon Parkway

Along the North Coast, sediments are moved by waves and currents in a largely unidirectional west to east transport. Erosion along PCH has increased in recent years and threatens the beaches, Hobson and Faria Parks, Old Pacific Highway and roadway, public access and ocean front residential communities as far south as the City of Ventura. There are similar vulnerabilities along the South Coast of the County. Sections 3.1 and 3.2 of this Report discuss the possibility of using non-permanent cross-shore features that function similarly to groins in trapping and retaining sand, yet do not permanently alter the coastline. Sediment management with retention structures is one of the few nature-based strategies available to mitigate erosion of critical infrastructure in high-energy coastline environments.

Potential Pilot Project

The potential pilot project would place three small cobble[64] features into a cross shore alignment at locations along the beach to increase sand retention (Figure B-6). These cross-shore features are based on existing sediment sizes on the North Coast and standard coastal engineering principles associated with groins which trap sand upcoast but would not be designed as permanent structures.

Figure B-6. Map view of cross-shore cobble groins with retained sand on the Rincon Parkway and at Faria County Beach Park (not to scale).

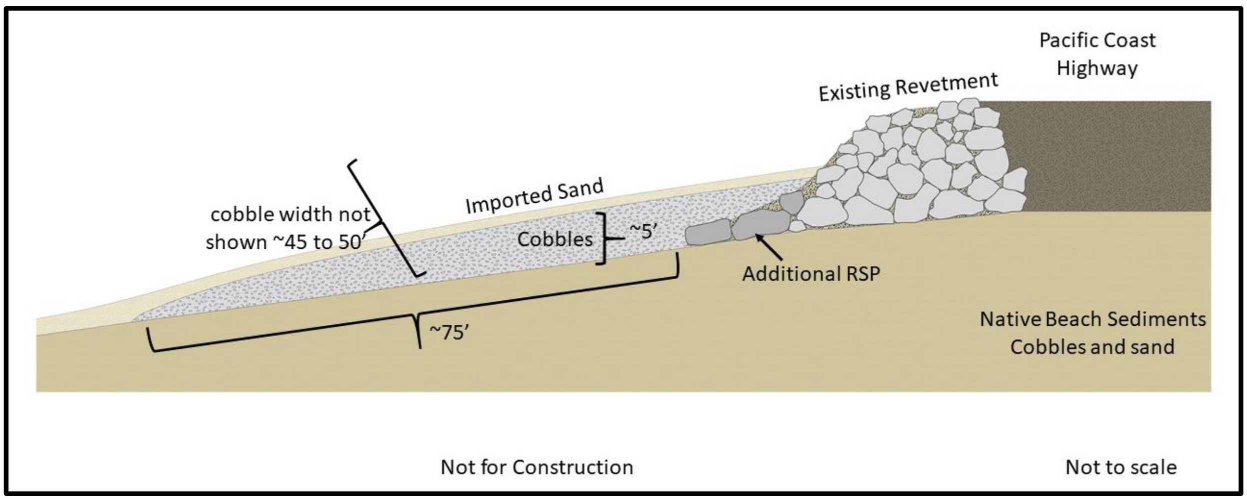
[64] Cobbles are small rounded rocks sized between a baseball to watermelon.

They would be designed to naturally settle into the surrounding environment and avoid costly removal or maintenance activities. They could be covered in sand during the gentle wave months in the summer and fall to encourage recreational use (see Figure B-7). More project specific geomorphic considerations, sediment analysis and coordination are necessary and would be included in subsequent, more detailed proposals.

Funding sources need to be identified. It is estimated that about 700 cubic yards would be needed for each cobble-based groin using the conceptual design dimensions shown in Figure B-7 below. Based on other adaptation projects estimates for groins[65] (~$4000/ linear foot), and Surfers' Point cobbles (~$3000/ linear foot) the estimated costs of each of these cobble groins could be between $225,000 to $300,000. Differences between these estimates likely relate to the transportation and engineering costs. Additional work to develop a design-level cost estimate would be necessary.

Presently, no funding is available from the Ventura County Watershed Protection District who maintains the County's flood control channels, but it is possible that the sediment can be provided at little to no cost. Plans and specifications for 200,00 cubic yards of sediment removal from a watershed near Camarillo were drafted in 2017, and the cost to remove the sediment from a Ventura County Watershed Protection District in-stream debris basin was estimated to be $2.2 million. This did not include transportation costs.

Figure B-7. Cobble-based groin concept in cross section (not to scale or for construction).



The project as described is expected to increase the residence time of any sand placed along the beach and may provide about a 2 to 5-year benefit to the Rincon Parkway and Faria Beach Park, and a much longer benefit by feeding downcoast beaches. Over time it should be assumed that the cobble cross shore retention features would evolve, and the cobbles become part of a shore parallel cobble beach berm similar to the cobble beach that is currently visible and occurs naturally at along the Faria Beach area and in downcoast locations.

[65] Revell, D. L., King, P., Calil J., Giliam, J.; City of Imperial Beach Sea Level Rise Assessment; September 2016; available at https://goo.gl/xiGzTn

While groins in the coastal engineering literature have often caused downcoast erosion, the use of smaller, more mobile cobbles of a lower height would avoid these potential downcoast impacts as they are reworked by waves over time and incorporated into the rock revetments already present at the site. The addition of a large volume of sand would also reduce or eliminate the potential for downcoast erosion impacts.

A complete failure of this project would result in the cobble berm rapidly migrating onto the beach and downcoast, and the retention function of the deposited nourishment would likely not last the anticipated five years. The sediment would continue to provide incremental benefits downcoast. With much of the site backed by shoreline armoring, no additional erosion impacts would be anticipated.

Project Benefits

The biggest benefits would be to augment beach compatible sediments in Northern Ventura County and the following:

- Reduce maintenance costs associated with the Old Coast Highway revetments that protect the scenic highway.
- Improve camping and beach recreation at County Parks and along the Rincon Parkway. Over time, downcoast beaches such as Solimar Beach and Mondos Cove would also benefit.
- Reduce greenhouse gas emissions by sourcing shoreline protection materials locally and within the same “sandshed”.
- Improve community flood safety by removing sediment from debris basins.
- Test a new coastal management technique to inform longer term future adaptation planning.

B.5 Limitations of the Study

This analysis was conducted on a very limited budget with limited data and a limited amount of time. All estimates are tentative. In particular, the vulnerability estimates assume that vulnerable property is perfectly protected from all other hazards. As an example, the same building cannot be both completely lost due to erosion and damaged by coastal flooding. For this reason, there is some double counting between the two figures that only becomes problematic when the estimated losses due to flooding and erosion are aggregated together.

Other limitations involve the idealized assumptions regarding damages and losses. In the case of tidal inundation there are currently standardized methods or estimates for the thresholds at which tidal nuisances become saftey hazards. Finally, estimates regarding the cost of maintenance are necessarily speculative, and do not take the increasing cost of sand, for example, into consideration. As such, analyses such as these should be revisited and updated on a regular basis.

B.6 Conclusion

Restoration of a native dune fronting both Hollywood and Silverstrand make sense economically in terms of reducing existing and future vulnerabilities with little impact expected to recreational uses. Additional considerations of reducing private flood insurance rates, reduced beach grooming costs, private and public aesthetics and potential habitat considerations warrant additional consideration for dune management.

Along the Rincon Parkway the revetment replacement with a seawall shows some recreational benefits but overall only makes marginal economic sense without additional adaptation measures to increase camping or parking revenues, retain sediment or place additional sediment opportunistically to help to maintain the sandy beach into the future.

Cobble-based groins present a nature-based pilot project strategy that could help to retain sediment on narrow beaches. However, such a project is relatively untested, as only cobble-based dunes and cobble berms have been successfully used.

Additional engineering analysis on the existing condition of the structures across the County, particularly along the Rincon Parkway, is recommended.

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