County of Orange AB 691 Sea Level Rise Assessment, Newport Bay

Draft

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Table of Contents

TABLE OF FIGURES

TABLE OF TABLES

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1. Introduction

Under California Assembly Bill 691 (AB-691), the County of Orange (County) is required to perform a Sea Level Rise (SLR) Vulnerability Assessment for its granted public trust tidelands within Newport Bay. The California State Lands Commission (CSLC) has jurisdiction over public lands, which include tidelands. Tidelands are sovereign land, held by the state of California where land is covered and uncovered by the ebb and flow of tides. The landward limit of tidelands is defined as the intersection of the mean high tide line with the shore. Tidelands can be granted to local trustees for purposes of commerce, navigation, fisheries, or other public trust purposes.

In 2013, the California legislature passed Assembly Bill 691, Chapter 592, which requires local trustees with average annual gross revenue greater than $250,000 from their public trust lands to prepare and submit an assessment of how they propose to address SLR to the CSLC by July 1, 2019.

In accordance with AB 691 assessment criteria, this study includes the following: an assessment of SLR impacts for 2030, 2050, and 2100 SLR scenarios, maps of projected SLR impacts, estimates of the financial costs of SLR, and a description of potential SLR adaptation strategies to protect and preserve tideland resources and structures.

1.1 Study Approach

This AB 691 SLR assessment for County tidelands within Newport Bay assesses potential impacts to coastal resources across multiple SLR scenarios. An inventory of County tideland coastal resources within Newport Bay was compiled as an initial step of the Vulnerability Assessment. Analyses then focused on the extent to which local coastal hazards are influenced by multiple SLR scenarios. The overlap of projected future hazard zones and coastal resources is used to identify future vulnerabilities and the SLR thresholds at which critical coastal tideland resources are impacted. Key questions that guide the SLR assessment are illustrated in Figure 1-1.

For the purposes of this study, a tideland resource is broadly defined as any natural or constructed feature that provides a benefit to the County. County tideland resources are grouped into the following categories: recreation and coastal access, submerged tidelands and waterways, boating infrastructure, and upland development and infrastructure. An inventory of those resources included in the SLR assessment may be found in Section 2.

The vulnerability of a tideland resource to SLR hazards is evaluated through an analysis of its exposure, sensitivity, and adaptive capacity. For this study, exposure refers to the type, duration, and severity of coastal hazards a specific resource is subject to under a given SLR scenario. Sensitivity represents the degree to which a resource is impaired by exposure to coastal hazards, and adaptive capacity refers to the ability of a resource to cope with changes in coastal hazards over time. These concepts are discussed further in

Section 6. A discussion of the specific coastal hazard analysis methodologies used in the study can be found in Section 5.

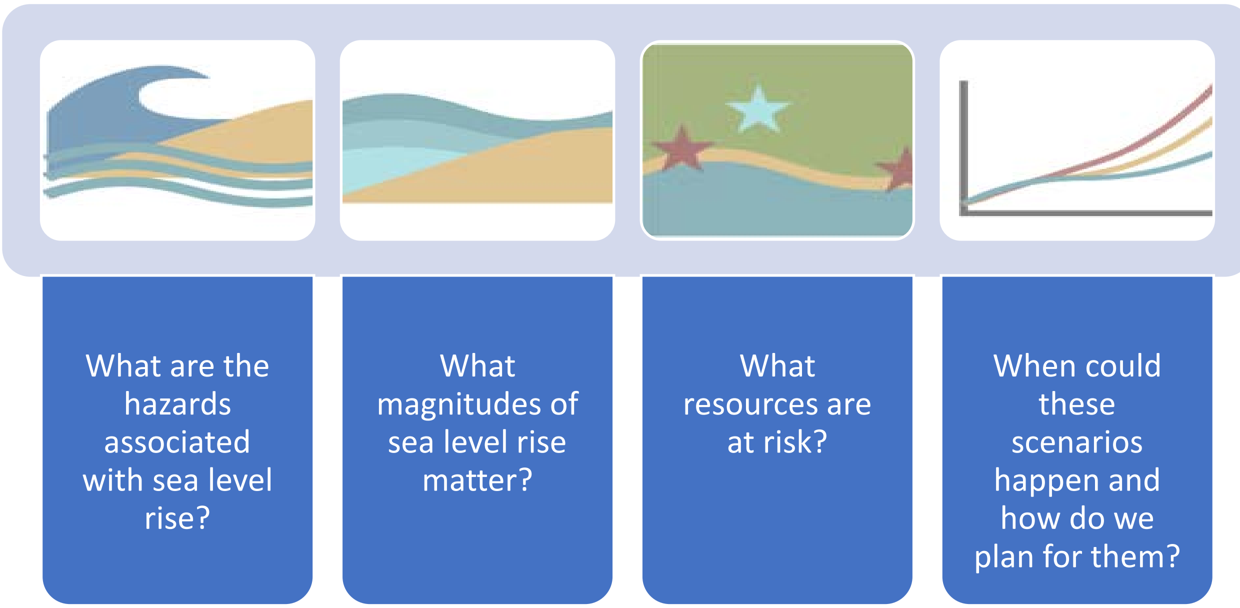


Figure 1-1: Key questions for a vulnerability assessment

1.2 Coastal Setting

Tidelands granted to the County of Orange are located throughout Upper Newport Bay and select portions of Lower Newport Bay (Figure 1-2). Newport Bay is located in Orange County within the City of Newport Beach. Upper Newport Bay, extending north of the Pacific Coast Highway, covers an area of approximately 1,000 acres, a large portion of which are designated as County tidelands. The primary source of freshwater flow into Upper Newport Bay is San Diego Creek, with additional freshwater inputs from the Santa Ana Delhi Channel.

The majority of Upper Newport Bay is wide and shallow, forming intertidal habitat areas such as mudflats and coastal wetlands. The center channel is dredged to maintain greater depth for sediment retention and navigational purposes. Lower Newport Bay, which has been dredged and developed into a marina, is connected to the ocean by the Newport Entrance Channel. Upper portions of the bay are eutrophic in nature due to nutrient discharges from surrounding urbanized areas. Water chemistry within the bay shows a high degree of diurnal variability due to the combination of oceanic and riverine inputs as well as high rates of respiration and organic matter decomposition. Benthic community structure and richness has also been shown to be seasonally variable, driven largely by seasonal patterns of rainfall and runoff into the bay.

County tidelands extend approximately 2.5 miles into Upper Newport Bay, including submerged areas as well as structures surrounding Newport Dunes and the Newport

Aquatic Center. Tideland shorelines in Upper Newport Bay vary between natural shallow tideland habitat areas, sandy beach areas, and bulkheads fronting developed shoreline. Tidelands within Lower Newport Bay surround areas of residential and commercial development. Bulkheads and attached recreational boating infrastructure make up the majority of tideland shoreline in Lower Newport Bay with the exception of a small sandy beach area adjacent to the Newport Beach Harbor Patrol building.

Figure 1-2: County of Orange tidelands located within Newport Bay

2. Coastal Resources

An inventory of coastal resources was created to identify resources, assets, land uses, and infrastructure potentially at risk within the study area. These resources were identified through a variety of methods including publicly available government databases, technical reports, and aerial imagery. The inventory of resources is summarized in Table 2-1 and focuses on all resources located on granted public trust tidelands within Newport Bay. Identified resources were mapped using GIS and may be found on the hazard overlay maps in Section 10.

Table 2-1: Inventory of coastal resources located within County of Orange tidelands

Resource Type	**Description**
Recreation and Coastal Access	Recreation and coastal access resources include sandy beach areas, parking facilities, and other coastal access points within the study area. The majority of these resources are located in the vicinity of Newport Dunes and the Newport Aquatic Center, with a small beach area also located adjacent to the Newport Beach Harbor Patrol building.
Submerged Tidelands and Waterways	Submerged tideland and waterway resources consist of any ecological resources that are either partially or fully inundated by tidal waters. Documented eelgrass habitats are included as part of the resource maps in this study, but various submerged resources exist throughout the study area. Analyses of these resources are generalized and based on major ecological parameters that could affect multiple habitat types.
Boating Infrastructure	Boating infrastructure includes any floating docks, gangways, boat launches, or pile-supported access structures. These resources are located along much of the shoreline within the study area.
Upland Development and Infrastructure	Any major structures within the study area are categorized as an upland development resource, including the Newport Aquatic Center, Back Bay Bistro, and Newport Dunes Resort and Marina as well as structures in the area of Newport Sea Base and Newport Beach Harbor Patrol.

3. Coastal Processes

3.1 Water Levels

The tides in Southern California are semidiurnal, meaning there are two low waters and two high waters each lunar day, an approximately 25-hour time period. The National Oceanographic and Atmospheric Administration (NOAA) operates tide stations throughout Southern California. The Los Angeles tide station (Station 9410660) provides a long-term sea level record near Newport Bay, which has a similar tidal range to that of the open ocean (Nezlin, Kamer, Hyde, & Stein, 2009). The station is located within Los Angeles Harbor and has collected data since 1923. Data from this station represent the most complete water elevation data relevant to Newport Bay and can be used to characterize the variability in existing water levels (Figure 3-1).

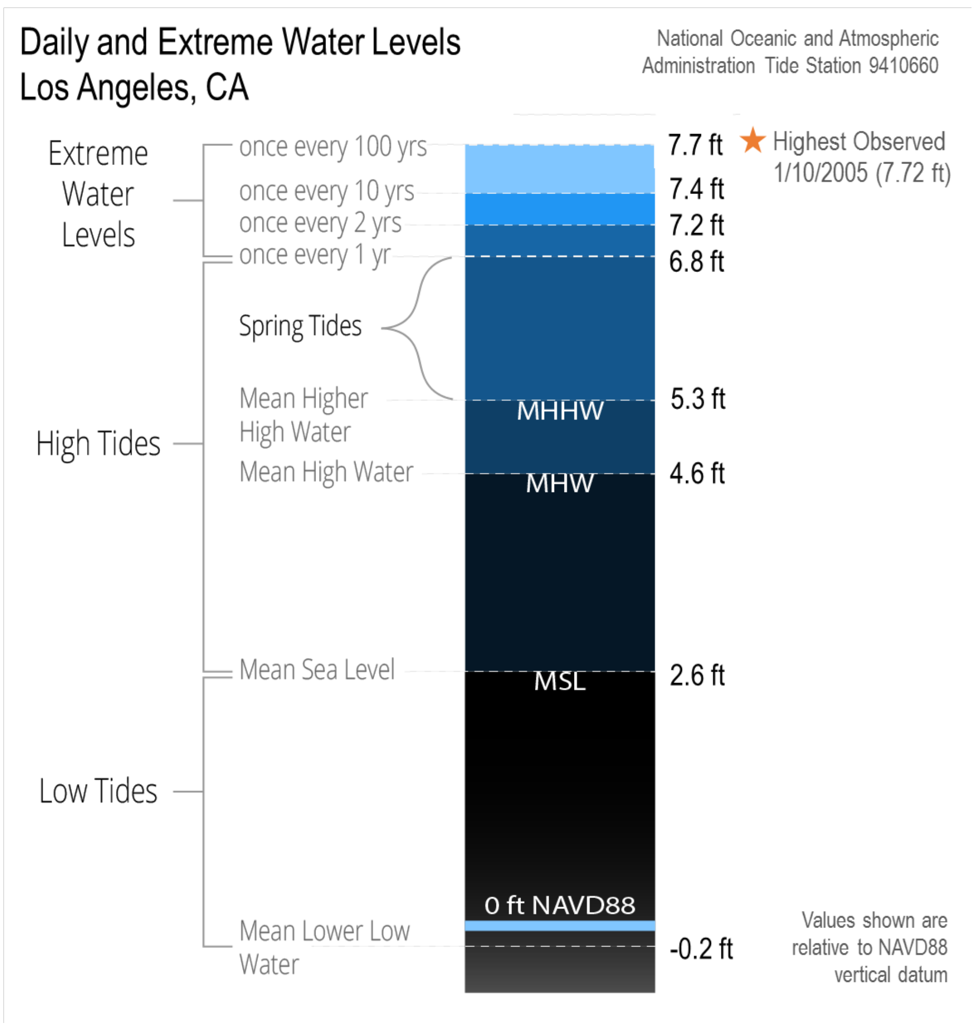


Figure 3-1: Los Angeles tidal datums and extreme water elevations from NOAA station 9410660.

Astronomical tides account for the most significant amount of variability in the total water level. Typical daily tides range from mean lower low water (MLLW) to mean higher high water (MHHW), a tidal range of about 5.5 feet. During spring tides, which occur twice per lunar month, the tide range increases to almost 7 ft due to the additive gravitational forces caused by alignment of the sun and moon. During neap tides, which also occur twice per lunar month, the forces of the sun and moon partially cancel each other out, resulting in a smaller tide range of about 4 ft. The largest spring tides of the year, which occur in the winter and summer, are sometimes referred to as “king” tides and result in high tides of 7 ft or more above MLLW and tidal ranges of more than 8 ft. Annual king tide events can lead to dry-weather or “nuisance” flooding in low-lying coastal areas, even in the absence of a storm or swell event.

Ocean water levels typically vary within predictable ranges; however, it is not uncommon to experience sea level anomalies due to events such as El Niño or storm surge that significantly increase the predicted water level above the normally occurring astronomical tide. These events can increase the predicted tides over the course of several days to several months. SLR will cause these anomalous tidal elevations to become more commonplace and severe as existing water levels rise across the entire tidal range.

3.2 Littoral Processes

Tidal flow is the primary factor affecting sediment transport within the tide-dominated estuary ecosystems of Upper Newport Bay due to the relatively low amount of wave energy present (Nezlin et al., 2009). Sediment is delivered from upstream freshwater sources, including San Diego Creek and the Santa Ana Delhi Channel, as well as from local erosion, although patterns of development surrounding the study area have likely modified the availability of external sediment (Rosencranz et al., 2016). The majority of sediment is delivered during winter months as levels of precipitation increase. Heavy rainfall can have significant impacts on surface depths within the study area, with past studies reporting approximately +2-ft increases in mid-channel depths following winter and spring rain events (Seapy, 1981). During dry periods Mediterranean-climate salt marshes can possess balanced sediment budgets. Given projected rates of SLR, a balanced sediment budget during dry periods may lead to geomorphic instability within low-lying coastal ecosystems, highlighting the importance of mineral sediment import and organic matter accumulation to SLR resilience (Rosencranz et al., 2016).

4. Sea Level Rise

4.1 Global and Regional Factors

SLR science involves analysis of both global and local physical processes, as illustrated in Figure 4-1. Numerical models are created based on the best scientific understanding of these global and local processes to provide predictions of future SLR. Global climate and oceanographic processes are complex and dynamic, and so modeling efforts and predictions are periodically updated to reflect any changes in scientific knowledge. On a global level, the most recent predictions come from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) released in 2013 (IPCC, 2013). The AR5 projections for SLR were 50% higher than the IPCC Fourth Assessment Report (AR4), released in 2007, due to the addition of updated information on ice sheet dynamics. At the state level, the California Coastal Commission (CCC) recommends using the best available SLR science, which is expected to be updated approximately every five years.

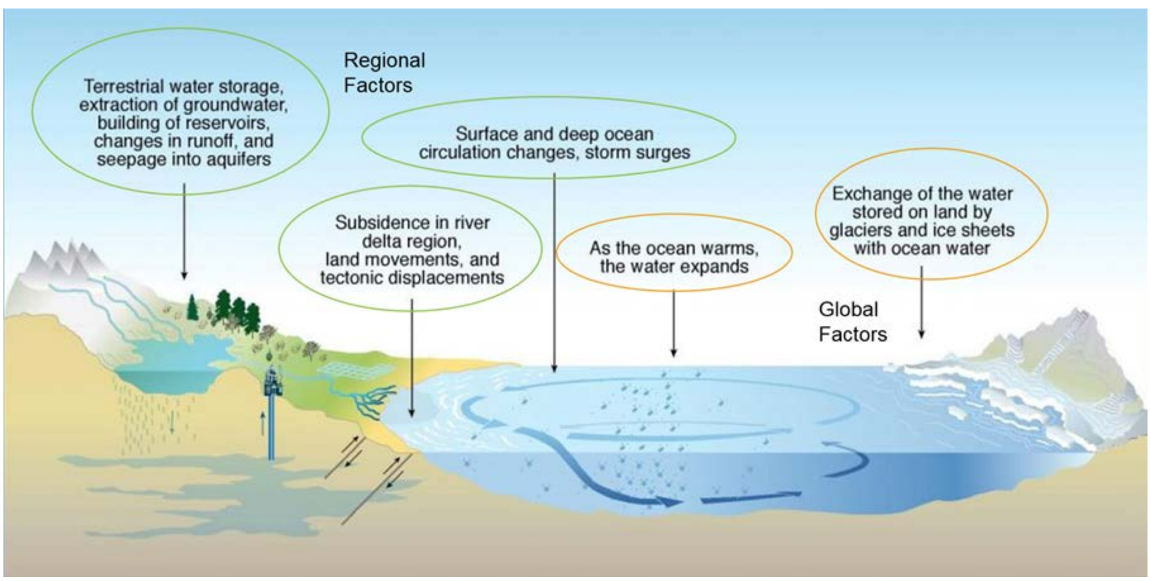


Figure 4-1: Global and regional factors that can contribute to changes in sea level

4.2 Sea Level Rise Projections

The State of California Ocean Protection Council (OPC) Science Advisory Taskforce recently compiled the best available SLR science relevant to California in its report *Rising Seas in California* (Griggs et al., 2017). This report was then used to update the OPC California State SLR Guidance in 2018 (California Ocean Protection Council, 2018). The 2018 OPC SLR Guidance is now referenced as the best available science throughout updated CCC SLR policy guidance documents.

The 2018 OPC guidance includes SLR projections for multiple emissions scenarios and uses a probabilistic approach based on Kopp et al., 2014 to generate a range of projections at a given time horizon for 12 tide gauges along the California coast. The projections for the Los Angeles tide gauge under a high-emissions scenario are referenced in this section. CCC SLR policy guidance recommends using projections associated with a high-emissions future given that worldwide emissions are currently following the high-emissions trajectory. The 2018 California State SLR Guidance document lays out a risk decision framework that provides recommendations on when to use low or high-risk aversion scenarios in the planning process. Along with this framework, the probabilistic SLR projections inform a decision-making process rather than trying to estimate the exact rate or level of SLR based on an individual scenario or projection.

CCC SLR guidance defines the likely range of SLR at a given time horizon as the central 66% of projections, or all projections bounded by the 17th and 83rd percentiles, based on methods from Kopp et al., 2014. For the 2030 time horizon, the likely range of SLR is 0.2 to 0.5 ft. At the 2050 time horizon, the likely range of SLR increases slightly to 0.5 ft to 1.0 ft. The likely range of SLR at the 2100 time horizon is 1.3 ft to 3.2 ft. The upper end of the likely range is recommended by the CCC for use in low-risk aversion situations in which impacts from SLR greater than this amount would be insignificant or easily mitigated. The state recommends this high-risk tolerance or low-risk aversion condition also be used when considering resources where the consequences of SLR are limited in scale and scope, with minimum disruption to and low impact on communities, infrastructure, or natural systems. This low-risk aversion curve is shown in orange in Figure 4-2. At a given time horizon, there is a 17% chance that SLR will meet or exceed these values based on current guidance.

For medium-high-risk aversion situations, the use of more conservative, or lower probability, SLR projections is recommended by the OPC Guidance. At a given time horizon there is a 0.5% chance that SLR meets or exceeds these levels, making them appropriate for use on projects where damage from coastal hazards would carry a higher consequence or in cases where the ability to adapt is limited, such as when dealing with residential and commercial structures. For these lower probability cases, SLR of 0.7 ft is projected at the 2030 time horizon, 1.8 ft is projected at the 2050 time horizon, and 6.7 ft is projected at the 2100 time horizon. The medium-high risk aversion curve is shown in red in Figure 4-2 and is most applicable for upland development.

The OPC guidance also includes a specific singular scenario (called H++), based on projections by Sweet et al., 2017 that incorporate findings of Pollard & Deconto, 2016 on potential Antarctic ice sheet instability, which could make extreme SLR outcomes more likely than indicated by Kopp et al., 2014 (Griggs et al., 2017). Because the H++ scenario is not a result of probabilistic modeling, the likelihood of this scenario cannot be determined. Due to the extreme and uncertain nature of the H++ scenario, it is most appropriate to consider when planning for development that poses a high risk to public health and safety, natural resources, or critical infrastructure (OPC, 2018). The H++ extreme risk aversion curve is shown in purple in Figure 4-2.

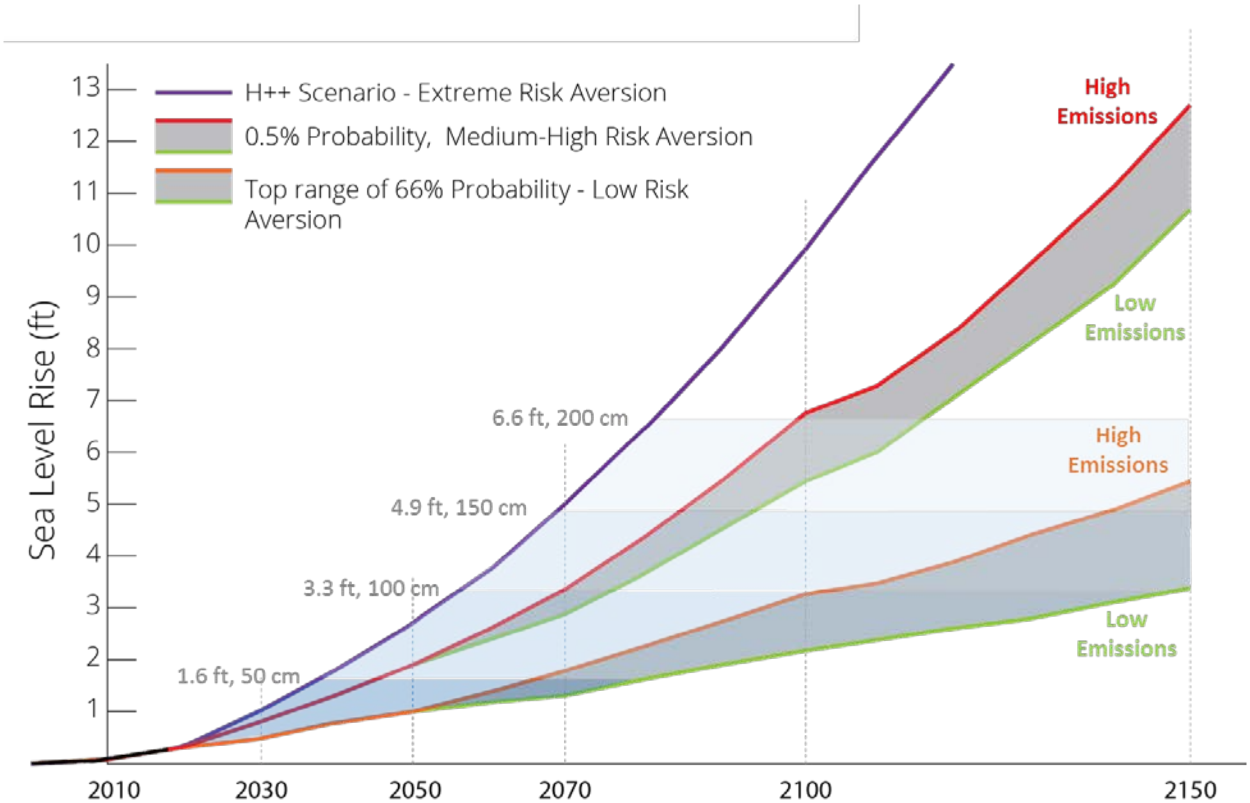


Figure 4-2: Approximate SLR projections for three risk aversion levels (OPC, 2018)

4.3 Selected SLR Scenarios

Climate science is a constantly changing field, often with high degrees of uncertainty. In the case of SLR in California, the OPC has high confidence in estimates to approximately year 2050, after which emissions scenarios cause predictions to diverge. Due to the high degree of uncertainty associated with predicting when and at what rate SLR will occur, this study looks at a range of SLR, starting with present day conditions and including levels appropriate for high risk aversion situations at the end of the century. Four scenarios have been selected for this study that consider increments of SLR between 0.8 ft and 6.6 ft. SLR scenarios are additionally based on available hazard data for the region, as discussed in Section 5. All levels of SLR and their corresponding recommendations for use based on time horizons and level of risk are described below. Coastal hazards under each increment of SLR were evaluated under both non-storm and 100-year storm conditions.

1. Sea level rise of 0.8 ft (25 cm) is representative of the medium-high-risk aversion projection for 2030 and the low-risk aversion projection for 2040.

2. Sea level rise of 1.6 feet (50 cm) is representative of the medium-high risk aversion projection for 2050 and the low risk aversion projection for 2070. Under the extreme H++ scenario, this amount of SLR could occur by 2040.

3. Sea level rise of 4.9 feet (150 cm) represents the medium-high-risk aversion projection for the 2080-2090 time horizon. If using projections for low-risk aversion conditions, this level of SLR corresponds to a time horizon beyond 2100; however, under the extreme H++ SLR scenario, this amount of SLR could occur by 2070.

4. Sea level rise of 6.6 feet (200 cm) is representative of the medium-high risk aversion projection for 2100. If considering extreme risk aversion this amount of SLR could occur by 2080. This scenario is included in addition to the 4.9-ft scenario to better reflect the full range of uncertainty surrounding long-term SLR projections and provides a conservative SLR estimate to be applied to projects with a longer design life (75-100 years) or resources where significant consequences are likely if SLR is underestimated.

5. Sea Level Rise Hazard Analysis

The effects of SLR on storm- and non-storm-related flooding were evaluated using results of the Coastal Storm Modeling System (CoSMoS) Version 3.0, Phase 2, a multi-agency effort led by the United States Geological Survey (USGS) to make detailed predictions of coastal flooding and erosion based on existing and future climate scenarios for Southern California. Other SLR hazard viewers such as the NOAA Sea Level Rise Viewer are also available, but these tools lack the regional focus and depth of information provided in CoSMoS modeling efforts.

The CoSMoS modeling system incorporates state-of-the-art physical process models to enable prediction of currents, wave height, wave runup, and total water levels (Erikson et al., 2017). A total of 10 SLR scenarios are available, increasing in 0.8-ft (0.25-m) increments from 0 to 6.6 ft (0 to 2 m), and include an extreme SLR scenario of 16.4 ft (5 m). CoSMoS modeling results provide predictions of shoreline erosion, cliff erosion, and coastal flooding under both average conditions and extreme events.

Hazard analyses for County Tidelands within Newport Bay focus primarily on coastal flood modeling results given the lack of erodible bluffs within the study area and limitations of CoSMoS shoreline erosion modeling in Upper Newport Bay, as discussed further in Section 5.3. The hazards depicted in this report are presented solely based on the assumptions and limitations accompanying the CoSMoS data available at the time of this study. No additional numerical modeling or independent verification of the CoSMoS data was performed.

5.1 Wave Modeling

Available CoSMoS storm scenarios include annual, 20-year, and 100-year return period storm events. Future storm conditions are downscaled from winds, sea-level pressures, and sea surface temperatures of an established global climate model (Erikson et al., 2017). Additional modeling was performed to translate projected deep water waves to shore, simulating additional regional and local wave growth. Due to the large geographical extent of CoSMoS modeling efforts, the same representative storm events are used across southern California to model wave impacts. Each of the selected representative storm events produces waves from a W-NW direction, typical of storm activity in winter months (Table 5-1). CoSMoS wave modeling results show minimal wave action within the study area with wave heights ranging from 0 ft to 0.5 ft. This is to be expected as the study area in Upper Newport Bay is heavily shadowed from open ocean wave energy by a barrier island.

Table 5-1: Boundary conditions associated with each CoSMoS modeled storm scenario

Scenario	Hs (m)	Tp (s)	Dp (degrees)	Maximum wind speed (m/s)
Background	1.75	12	286	NA
1-year storm #1	4.39	16	284	22.8
20-year storm #1	5.86	18	281	22.3
20-year storm #2	6.13	18	292	28.7
100-year storm #1	6.20	16	264	26.6
100-year storm #2	6.80	18	287	30.3

5.2 Coastal Flood Projections

CoSMoS coastal flooding projections simulate the effects of erosion, wave runup, and overtopping during storm events. Coastal flood extents are calculated and mapped at profiles spaced approximately 300 ft along the shoreline. The projected coastal water levels used in flood mapping consider future shoreline change, tides, sea level anomalies like El Niño, storm surge, and SLR. Future wave conditions used in the model are based on forecasted conditions out to year 2100. All flood events are modeled in conjunction with a high spring tide, a tide height that occurs approximately twice a month, to represent a near worst-case scenario (Erikson et al., 2017).

CoSMoS coastal flood modeling results assume that future shoreline retreat will be halted at the existing development line and that no beach nourishment events will occur to maintain existing beach widths. Shoreline erosion projections are modeled with the CoSMoS Coastal Online Assimilated Simulation Tool (COAST), which includes a suite of models that consider historic erosion trends, long-shore and cross-shore sediment transport, and shoreline changes due to increased water levels (Erikson et al., 2017). Although potential shoreline retreat is halted, projected coastal flood extents are permitted to extend beyond the line of development.

Assumptions regarding the specific type, height, and shoreline profile of existing coastal protection structures are not immediately available for large-scale modeling efforts such as CoSMoS. These parameters are key in providing precise evaluations of the wave runup height and potential for flooding landward of specific structures, and thus it may be prudent to verify CoSMoS findings in a subsequent coastal flood modeling effort. This applies to developed shorelines of the study area, such as the Newport Sea Base, where the bulkhead wall crest elevation may not be accurately captured in the CoSMoS digital elevation model (DEM).

5.3 Limitations of CoSMoS Projections in Upper Newport Bay

Several aspects of the CoSMoS modeling system are not fully applied within the study area due to the location of the COAST erosion model boundary, which runs along the ocean-facing coastline and does not extend into Upper Newport Bay (Figure 5-1). Because the COAST model is not present past the immediate coastal shoreline, CoSMoS coastal flood projections along interior bay shorelines do not include any modeled effects of shoreline erosion, wave runup, or wave overtopping. Flood projections are instead based solely on the relationship between current coastal topography and projected future water level elevations under storm and non-storm conditions. Although impacts from wave runup and overtopping are likely to be minor within Upper Newport Bay due to minimal wave heights, any increased shoreline erosion stemming from SLR may further exacerbate CoSMoS coastal flood projections and pose further risk to shoreline resources within the study area.

Figure 5-1: COAST model boundary

6. Vulnerability Assessment

The vulnerability assessment provides a qualitative evaluation of coastal resources that could be impacted by future SLR hazards based on projections and methodologies discussed in Sections 4 and 5. The purpose of this assessment is to identify what resources are vulnerable at each increment of SLR to inform County planning efforts.

The intersection of potential SLR hazard zones and County tideland resources was determined using Geographic Information System (GIS) software. Methodology for assessing vulnerabilities and risk were based on guidelines published within the reports *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* (Snover et al., 2007) and *California Adaptation Planning Guide, Planning for Adaptive Communities* (California Emergency Management Agency & California Natural Resources Agency, 2012).

In accordance with these and other state SLR planning guidelines (California Coastal Commission, 2015), overall SLR vulnerability for each resource is assessed as a function of exposure, sensitivity, and adaptive capacity. These terms, in the context of how they are used within this vulnerability assessment, are defined as follows:

- **Exposure**: The degree to which a system or asset is exposed to SLR. In this study, asset exposure to projected SLR was determined through numerical modeling and mapping and is defined in terms of flooding and inundation.
- **Sensitivity**: The degree an asset would be impaired by the impacts of SLR. Systems that are greatly impaired by small changes in SLR have a high sensitivity, while systems that are minimally impaired by the same small change in SLR have a low sensitivity.
- **Adaptive Capacity**: The ability of an asset to respond to SLR, to moderate potential damages, to take advantage of opportunities, and to cope with the consequences. This does not mean that the system must look the same as before the impact, but it must provide comparable services and functions with minimum disruption or additional cost.

The vulnerability of an asset increases with both exposure and sensitivity, while adaptive capacity is inversely related to vulnerability, illustrated in Figure 6-1. As an example, large residential structures typically have a high sensitivity to SLR hazards because even minor flooding or erosion can cause significant and costly damages. Large structures may also have a low adaptive capacity to SLR in that they cannot be easily relocated or raised to cope with consequences, compounding overall vulnerability. An alternative example would be structures such as floating docks, which are highly exposed to coastal hazards but often maintain a low vulnerability to SLR because they can easily adapt to increasing water levels.

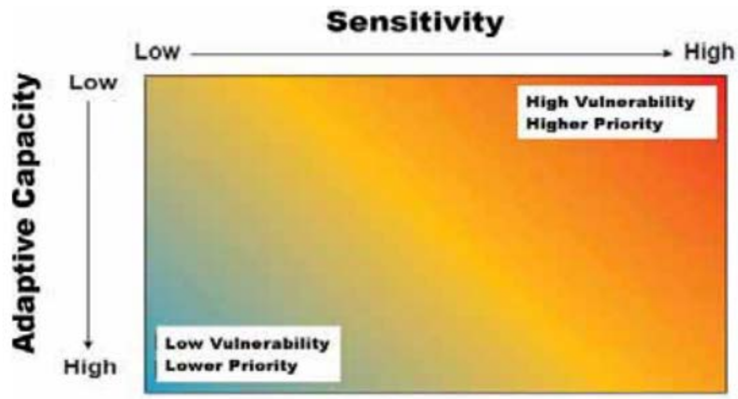


Figure 6-1: Relationship between sensitivity, adaptive capacity, and vulnerability (ICLEI, 2012)

6.1 Recreation and Coastal Access

6.1.1 Exposure

Flood projections under a 0.8-ft SLR scenario show minimal hazard exposure for the majority of recreation and coastal access resources. The most significant area exposed under this scenario is the sandy beach east of the Newport Beach Harbor Patrol, where non-storm flood projections extend approximately 100 ft landward of the current shoreline. Storm flood projections also extend into Newport Sea Base parking areas with 0.8-ft SLR. Hazard exposure remains limited under a 1.6 ft SLR scenario, with flood projections showing only marginal increases within sandy beach areas. Flood projections within Newport Sea Base parking areas show a shift in exposure from temporary storm flooding to more frequent non-storm flooding under this scenario.

The hazard exposure of recreation and coastal access resources increases significantly under a 4.9ft SLR scenario. The primary parking areas for Newport Sea Base, the Newport Beach Harbor Patrol, and Newport Dunes Marina are all projected to become inundated under non-storm conditions with 4.9 ft SLR. Additional storm and non-storm flood impacts are also projected within areas of the large parking lot serving the Newport Dunes Resort, Back Bay Bistro, and nearby boat launch. Sandy beach areas also become heavily exposed to flood hazards with 4.9-ft SLR, with minimal beach area remaining east of the Newport Beach Harbor Patrol and within the Newport Dunes recreational area. Storm flood projections also extend into the Newport Dunes campground under this scenario. Hazard exposure is less severe within North Star Beach, where flood projections show approximately 35 ft of shoreline retreat.

Additional hazard exposure is projected for several recreation and coastal access resources under a 6.6-ft SLR scenario. All parking areas serving the Newport Aquatic Center and North Star Beach are projected to become inundated under non-storm conditions under this scenario along with the majority of the large parking area serving

Newport Dunes Resort and nearby resources. Secondary parking lots and boat storage areas serving the Newport Dunes Marina also become exposed to storm flooding under this scenario. Remaining sandy beach areas are limited to select areas of North Star Beach as flood projections grow to completely cover the Newport Dunes area. Storm flood projections further reduce remaining areas of North Star Beach, separating the beach into two separate sections. Non-storm flood projections also extend across the majority of the Newport Dunes campground with 6.6 ft of SLR, with additional storm flooding resulting in almost complete inundation of the area.

6.1.2 Sensitivity

The hazard sensitivity of recreation and coastal access resources within the study area is primarily influenced by disruptions to use rather than potential structural damages. Parks, sandy beaches, campgrounds, and associated parking areas are unlikely to experience major structural damage during temporary storm flooding as floodwaters are free to advance and recede, but the public utility of these resources can be significantly reduced if recurring non-storm flooding prevents use of or access to these areas. This loss of access and utility or recreational resources is likely to occur under long-term SLR scenarios in the absence of mitigation efforts due to the widespread nature of non-storm flood projections.

6.1.3 Adaptive Capacity

The adaptive capacity of recreational and coastal access resources within the study area is generally high, although investment in adaptation would be required. This is due in part to a lack of large engineered structures that often require more intensive and financially demanding flood mitigation measures. In the absence of major structures, resources such as parking lots or campgrounds can be more easily elevated or redesigned to address increased flood risk over time. Adaptation options for sandy beach areas are largely dependent on the availability of open space landward of current beach areas. Beaches backed by development such as those seen in Newport Dunes have limited capacity for landward retreat as SLR increases. This is less of a concern at North Star Beach, where higher elevation and additional beach width provide a buffer against SLR impacts. Additional beach nourishment efforts or realignment of landward resources can each be employed to offset any impacts and maintain current beach widths.

6.1.4 Short-term SLR Vulnerability – 2030 to 2050 (0.8 ft, 1.6 ft)

Recreational and coastal access resources within the study area have a low overall vulnerability to short-term SLR hazards. This is due in large part to limited hazard exposure, with only select areas of Newport Sea Base and the Newport Harbor Patrol projected to become flooded under a 0.8 ft- or 1.6-ft SLR scenario. Flood depths remain shallow under each scenario and are limited in extent. These impacts can likely be offset through relatively minor increases in shoreline elevation or localized protection measures at each site.

6.1.5 Long-term SLR Vulnerability - 2100 (4.9ft, 6.6ft)

Recreation and coastal access resources are more vulnerable to long-term SLR hazards. Non-storm flood projections under a 4.9-ft SLR scenario cover significant areas of these resources, and only limited areas remain available with 6.6 ft of SLR. Any areas subject to frequent non-storm flooding are likely to experience a significant decline in public utility as access becomes disrupted on a regular basis. Of particular concern is the sandy beach area within Newport Dunes, which is projected to become almost entirely inundated under non-storm flood conditions with 4.9 ft of SLR. Adaptation measures, such as beach nourishment and elevation or realignment of coastal resources, remain as options to mitigate potential impacts, especially under a 4.9-ft SLR scenario where flood projections are primarily limited to low-lying portions of the shoreline. Adaptation remains possible under a 6.6-ft SLR scenario but is complicated by reduced open space landward of recreation and coastal access resources within the study area.

6.2 Submerged Tidelands and Waterways

6.2.1 Exposure

Submerged tidelands and waterways can be exposed to SLR hazards in multiple ways. Ecological resources that are currently fully submerged throughout the tidal cycle may experience hazard exposure through increased water depth. Resources that are currently partially or fully inundated at certain points of the tidal cycle may be inundated with greater frequency and at a higher magnitude with SLR, potentially increasing areas that remain permanently submerged and squeezing out intertidal habitat.

Flood projections under current conditions cover the entirety of submerged tidelands and waterways within the study area. This is expected as CoSMoS flood projections represent high spring tide conditions. Although flood projections under each SLR scenario do not cover any additional areas of current submerged tidelands and waterways, flood depths within these areas increase according to the level of SLR evaluated. SLR hazard exposure within these areas is also likely to occur based on shifts of the entire tidal cycle in addition to increased flood extents and depths at tidal maximums.

Although CoSMoS flood projections are not available for elevations below high spring tide conditions, estimates of submerged tideland and waterway exposure to SLR can be made based on the current normal tidal range within Upper Newport Bay of approximately 5.5 ft. Under a 0.8-ft SLR scenario, any submerged tidelands that currently become dry during the lower 15% of the normal tidal cycle will become permanently inundated across this tidal range. Tideland areas that remain dry in the lower 30% and 90% of the current normal tidal cycle become exposed to permanent inundation over a normal tidal range under 1.6-ft and 4.9-ft SLR scenarios, respectively. Under a 6.6-ft SLR scenario, all submerged tideland areas that become dry at any point in the current normal tidal cycle will be permanently inundated at a minimum depth of approximately 1 ft over a normal tidal range.

6.2.2 Sensitivity

The hydrologic characteristics of submerged tidelands and waterways play a critical role in ecosystem structure and function. Dynamic patterns of salinity and complex flood regimes within ecosystems such as Upper Newport Bay have a large influence on plant growth and community composition. Changes in water elevations relative to tideland ecosystems due to SLR can disrupt the feedback mechanisms between hydrological, ecological, and geomorphological processes that are involved in maintaining tideland ecosystem stability (Stagg, Cormier, & Conner, 2016). Such changes may lead to large ecological shifts within the study area, particularly if current intertidal ecosystems become permanently inundated. Ecosystem services within the study area may also be diminished due to the loss or alteration of highly productive marsh, wetland, and other tideland habitats.

6.2.3 Adaptive Capacity

Due to the complex and dynamic nature of tideland ecosystems, the preservation of current ecological functions and services within the study area depends largely on maintaining elevation relative to sea level. This can be accomplished through incremental elevation of existing areas or gradual landward retreat of tideland ecosystems. In the absence of targeted adaptation efforts, tideland habitats such as coastal wetlands can respond to SLR by gaining elevation through complex feedbacks between surface elevation, sediment accretion, and plant growth, representing a potential inherent SLR resilience mechanism (Stagg et al., 2016). Although inherent resilience may exist, studies of sediment fluxes within Southern California salt marshes show a balanced sediment budget during dry periods, indicating potential instability as rates of SLR increase (Rosencranz et al., 2016).

If local rates of accretion are not sufficient to maintain surface elevation relative to SLR, tideland ecosystems may require additional inputs to keep pace with current and predicted rates of SLR. Accretion rates within tideland ecosystems can be increased in several ways including the removal of landscape modifications that limit the availability of external sediment, increased vegetation to increase sediment retention, and direct import through methods such as thin-layer placement. Landward migration of tideland areas is also a potential avenue for adaptation but may be difficult to implement within the study area due to a lack of open space at higher elevations and patterns of development surrounding Upper Newport Bay.

Figure 6-2: Thin-layer sediment placement within the Seal Beach National Wildlife Refuge (M&N, 2016)

6.2.4 Short-term SLR Vulnerability – 2030 to 2050 (0.8ft, 1.6ft)

Submerged tidelands and waterways may have some degree of vulnerability to short-term SLR hazards based on shifts in tidal water levels. The overall vulnerability of these resources will depend largely on whether accretion rates within tidelands are sufficient to offset SLR and the degree to which any SLR-driven ecological shifts affect ecosystem structure and function within the study area. These effects are likely to be more manageable in the short term, due to lower rates of SLR and increased certainty surrounding SLR projections, providing greater opportunity for ecosystem monitoring and potential application of adaptation strategies.

6.2.5 Long-term SLR Vulnerability – 2100 (4.9 ft, 6.6 ft)

Submerged tidelands and waterways within the study area have a greater vulnerability to long-term SLR hazards due to potential acceleration of SLR beyond 2050. Accelerated rates of SLR may widen the gap between rates of accretion and increases in water elevation within the study area, potentially exacerbating any ecological impacts. Long-term SLR projections are also more likely to result in a shift from intertidal to subtidal ecosystems over a significant portion of the study area. Though the potential exists for widespread ecological impacts within the study area, the long-term time frame of these impacts provides additional opportunities for data-gathering and development of adaptation solutions. A key step to mitigating long-term vulnerability of submerged tidelands and waterways within the study area is identifying the critical parameters that can alter ecological processes and feedbacks that contribute to the inherent resilience of the system.

6.3 Boating Infrastructure

6.3.1 Exposure

Projected SLR hazard exposure for boating infrastructure is limited under a 0.8-ft SLR scenario. Any increment of SLR will raise floating infrastructure and reduce freeboard of piers, but flood projections beyond the current shoreline with 0.8 ft of SLR are seen only within the Bayshore Marina and a small area east of Newport Sea Base under storm conditions. Under a 1.6-ft SLR scenario, Newport Sea Base, Bayshore Marina, and Newport Beach Boat Launch infrastructure are projected to be exposed to non-storm flood hazards. Storm flood projections for this scenario show additional hazard exposure for boating infrastructure within the Newport Dunes Marina and select areas of Linda Island and Marco Island.

The hazard exposure of boating infrastructure is projected to increase substantially under a 4.9-ft SLR scenario. Non-storm flood hazards are projected to impact all boating infrastructure within the study area under this scenario, with the potential exception of the Newport Aquatic Center boat dock. Storm flood conditions further exacerbate these hazard projections. Hazard projections under a 6.6-ft SLR scenario again cover all boating infrastructure, with additional elevation resulting in more frequent and severe flood impacts.

6.3.2 Sensitivity

The sensitivity of boating infrastructure to SLR hazards is highly dependent on whether water levels exceed the design of the structure, which in many cases is the elevation where the dock or pier meets the shoreline or other access points. Water-side boating infrastructure generally has very little sensitivity to flood levels, as floating docks are designed to accommodate frequent changes in water level, provided the guide piles are high enough to support the floating docks. Flood elevations that exceed the top of pile elevation, or bulkhead elevation are likely to cause a significant increase in structural damage and impede use. This is especially true if flood elevations extend above shoreline anchor points under non-storm conditions, leading to recurring damages and loss of access on a regular basis.

6.3.3 Adaptive Capacity

Boating infrastructure is highly adaptable to SLR hazards. Piers and docks are able to accommodate gradual increases in water elevations without intervention due to their water-dependent nature, provided that flood elevations remain below critical design thresholds. The relatively short design life of floating docks present throughout the study area also provides opportunity for continual design updates as SLR increases and future hazard projections are refined. Pile-supported pier structures or more heavily engineered boating infrastructure, such as the Newport Beach Boat Launch, will likely require more long-term SLR hazard adaptation mitigation efforts due to the additional cost of elevating or relocating such structures.

6.3.4 Short-term SLR Vulnerability – 2030 to 2050 (0.8 ft, 1.6 ft)

The overall vulnerability of boating infrastructure within the study area is low when considering short-term SLR hazard projections. Hazard exposure is limited to select areas primarily under major storm conditions. Short-term vulnerability is also mitigated by the low sensitivity and high adaptive capacity of these resources. Any infrastructure exposed to short-term SLR hazards, such as the piers and docks within the Bayshore Marina, will likely be able to accommodate increased SLR in the near term. Over the long term, this infrastructure can adapt by programming SLR into the life cycle improvements specific to each location.

6.3.5 Long-term SLR Vulnerability – 2100 (4.9ft, 6.6ft)

Boating infrastructure is significantly more vulnerable to long-term SLR hazards due to widespread hazard exposure under both storm and non-storm conditions. Flood projections under both the 4.9-ft and 6.6-ft SLR scenarios extend well beyond the current shoreline within the study area, impacting both water-side and landside infrastructure. This is likely to cause extensive structural damages and loss of access as flood elevations extend past critical design thresholds. Despite the potential for widespread damages to boating infrastructure, adaptive capacity remains present due to the necessary periodic replacement or redesign of these structures. Long-term SLR hazard vulnerability can be reduced dramatically if these periodic boating infrastructure updates continually account for SLR hazards through measures such as increased elevation or gradual landward relocation.

6.4 Upland Development and Infrastructure

6.4.1 Exposure

No upland development within the study area is projected to be exposed to SLR hazards under a 0.8-ft SLR scenario. Under a 1.6-ft SLR scenario, storm flood hazard projections extend across several upland structures within the Newport Dunes Marina and Newport Sea Base. Upland development flood hazard exposure for non-storm conditions remains low with 1.6-ft SLR.

Non-storm flood hazard exposure increases with 4.9 ft of SLR. Under this scenario, non-storm flood projections cover upland structures throughout the study area, including the Newport Beach Harbor Patrol, Newport Sea Base, Newport Dunes Marina, and the Back Bay Bistro. Storm flood conditions with 4.9 ft of SLR result in marginal increases in projected flood extents and do not include any new areas of upland development. Non-storm flood projections extend further inland under a 6.6-ft SLR scenario, inundating areas surrounding the Newport Aquatic Center and Newport Dunes Resort. Storm flood projections with 6.6 ft of SLR fully cover the Newport Aquatic Center, Back Bay Bistro, and outer portions of select structures within the Newport Dunes Resort.

6.4.2 Sensitivity

Upland development within the study area is highly sensitive if exposed to SLR flood hazards. Habitable structures often experience extensive damage when flooded, even if flooding is temporary or at a relatively shallow depth. The time required to repair structures following flood events also represents a significant impact to the utility of upland infrastructure. This is especially a concern when considering non-storm flooding projected to occur on a regular basis. In the absence of mitigation efforts, structures exposed to non-storm flooding are likely to require frequent repairs and may remain inaccessible to the public for significant time periods throughout the year. Structural design features such as wet or dry floodproofing can reduce hazard sensitivity to some extent. These are most often seen in structures that have a coastal-dependent use or those that are located in close proximity to the shoreline.

6.4.3 Adaptive Capacity

A number of adaptation measures can be employed to mitigate SLR hazards for upland infrastructure, but adaptation under more severe SLR scenarios may require greater investment as compared to other resources within the study area. Enhancements to existing shoreline protection or structural accommodation such as retrofitting or floodproofing can be employed to address temporary flooding or minor tidal flooding of upland infrastructure. More severe flood hazards can potentially be addressed over time through additional measures such as elevation of select structures. Relocation or realignment of waterfront development also remains an option for facilities at the Newport Dunes Marina or the Back Bay Bistro, where open space exists landward of current structures.

6.4.4 Short-term SLR Vulnerability – 2030 to 2050 (0.8ft, 1.6ft)

Overall short-term vulnerability is low for upland development and infrastructure within the study area. Hazard exposure is limited to temporary flood hazards during major storm events at Newport Sea Base and the Newport Dunes Marina under a 1.6-ft SLR scenario. Structures within these areas may be sensitive to these hazards, but these impacts can likely be mitigated or avoided through localized adaptation efforts due to the limited extent of flood projections.

6.4.5 Long-term SLR Vulnerability – 2100 (4.9ft, 6.6ft)

Infrastructure within several upland areas becomes vulnerable to SLR hazards under long-term SLR scenarios. Under a 4.9-ft SLR scenario projections show Newport Sea

Base, the Newport Beach Harbor Patrol, Newport Dunes Marina, and outer portions of the Back Bay Bistro are exposed to non-storm flood hazards. Hazard projections under a 6.6-ft SLR scenario show further exposure in these areas and additional exposure of the Newport Aquatic Center and Newport Dunes Resort. Flooding of upland infrastructure is likely to lead to extensive structural damage due to the high hazard sensitivity of these structures, particularly if flooding occurs regularly under non-storm conditions. Adaptation efforts will be necessary to offset projected damage to upland infrastructure under more severe SLR scenarios. The extended planning horizon and broad range of hazard mitigation options available for upland areas provide opportunities for adaptation that could significantly reduce long-term vulnerability.

7. Economic Impacts

County of Orange tidelands generate revenue through rents and concessions as well as fees paid for parks and recreation services. Total County tideland revenue was greater than $4 million in financial year 2016-2017, accounting for the vast majority of overall tideland revenue. Newport Dunes Marina and Resort represents the largest individual source of revenue at approximately $3 million. Given that the majority of tidelands revenue is generated from rents and concessions, the estimate of financial impacts evaluated the potential for structural damage to these facilities under each SLR scenario. This provides an indication of where and when the potential for structural damage and, therefore, impacts to this revenue stream may occur; however, this analysis is not intended to be a comprehensive economic review of all direct and in-direct impacts resulting from SLR and coastal hazards.

7.1 Structural Damages

Potential damages to structures within County of Orange tidelands resulting from SLR and coastal hazards are based on depth-damage relationships, established through the USACE North Atlantic Coast Comprehensive Study (NACCS) and designed to better capture damage due to coastal storms and flood events as opposed to riverine flooding (U.S. Army Corps of Engineers, 2015a, 2015b). The USACE provides estimates of minimum, most likely, and maximum damages to structures as a percentage of total structure value. Flood damage estimates due to inundation are based on USACE prototype structure types found within the study area. Individual damage assessments are provided for major structures within County tidelands using NACCS Prototype 2: Commercial Engineered. The depth damage function for Prototype 2 shows a significant increase in potential damages from 1 ft to 3 ft of flood depth, with 50% damage occurring at a flood depth of 6 ft to 7 ft, as illustrated in Figure 7-1.

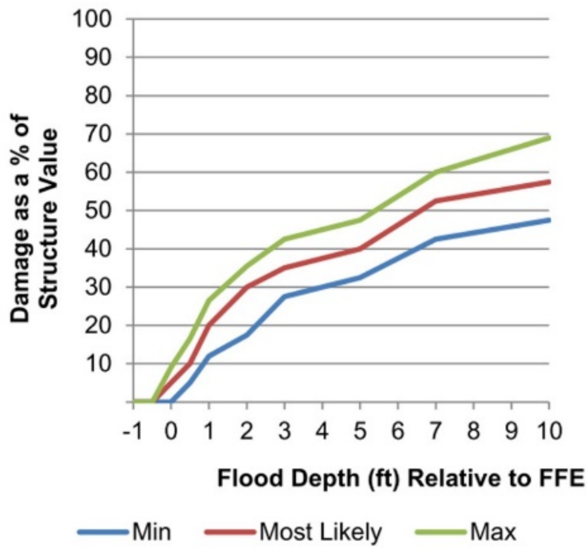


Figure 7-1: NACCS structure prototype 2 depth damage function

For each prototype considered in the NACCS report a minimum, maximum, and most likely depth damage function is provided. The range of expected damage is a function of individual building characteristics including structure type, age, utility location, and condition. These characteristics for NACCS Prototype 2 are listed in Table 7-1. The full range of damage potential is included in this analysis, given the limited available data on many of these individual building characteristics.

Table 7-1: NACCS Prototype 2 building characteristics associated with each damage estimate.

Structure Characteristics	Minimum	Most Likely	Maximum
Stories	2	2	2
Foundation	Slab	Slab	Slab
Structure Type	Reinforced concrete	Steel frame; precast infill	Steel frame with light cladding
Cladding	Concrete panels	Moderate cladding	Light cladding
Finished Floor Height	0'-0''	0'-0''	0'-0''

7.1.1 Newport Beach Harbor Patrol

Minimal structural damage is projected for Newport Beach Harbor Patrol structures under 0.8-ft and 1.6-ft SLR scenarios for both storm and non-storm conditions. Damage estimates become substantial under a 4.9-ft SLR scenario, with likely damages under storm conditions exceeding one-third of total structural value. Damage estimates rise incrementally under a 6.6-ft SLR scenario, notably for non-storm conditions where likely structural damage increases from 20 % to 35 %. Complete structural and content damage estimates for Newport Beach Harbor Patrol are presented in Table 7-2 and Table 7-3.

Table 7-2: Potential damages for Newport Beach Harbor Patrol under non-storm conditions.

SLR (ft)	Structure Damage %			Perishable Content Damage %		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	0	0	0	0	0	0
4.9	12	20	27	17	35	50
6.6	28	35	43	37	43	65

Table 7-3: Potential damages for Newport Beach Harbor Patrol under 100-year storm conditions.

SLR (ft)	Structure Damage %			Perishable Content Damage %		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	0	0	0	0	0	0
4.9	28	35	43	37	43	65
6.6	33	40	48	43	47	65

7.1.2 Newport Sea Base

Minimal damage is projected for Newport Sea Base structures for both the 0.8-ft and 1.6-ft SLR scenarios under non-storm conditions. Some degree of structural damage is projected for storm conditions under a 1.6-ft SLR scenario, ranging from as little as 5% to a maximum of 17%. Damage projections increase significantly under 4.9 ft and 6.6 ft of SLR scenarios, with likely storm damage estimates rising above 50% of structural value with 6.6 ft of SLR. Complete structural and content damage estimates for Newport Sea Base are presented in Table 7-4 and Table 7-5.

Table 7-4: Potential damages for Newport Sea Base under non-storm conditions.

SLR (ft)	Structure Damage %			Perishable Content Damage %		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	0	0	0	0	0	0
4.9	18	30	36	28	39	58
6.6	33	40	48	43	47	65

Table 7-5: Potential damages for Newport Sea Base under 100-year storm conditions.

SLR (ft)	Structure Damage %			Perishable Content Damage %		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	5	10	17	5	18	28
4.9	28	35	43	37	43	65
6.6	43	53	60	50	70	90

7.1.3 Newport Dunes Marina

For the purposes of this assessment, the scope of marina damages are limited to landside buildings. Other marina infrastructure, such as docks, gangways, and utilities, may experience damages under lower SLR scenarios. Minimal structural damage is projected for Newport Dunes Marina under a 0.8-ft SLR scenario. Damage projections remain minimal for non-storm conditions under a 1.6-ft SLR scenario. Structural damage may occur during storm conditions under this scenario, but likely damage estimates remain relatively low at 10% of structural value. Likely damage estimates rise to 35% and 40% of structural value under a 4.9-ft SLR scenario for non-storm and storm conditions respectively. Likely structural damage projections for storm conditions under a 6.6-ft SLR scenario extend above 50% of structural value.

Table 7-6: Potential damages for Newport Dunes Marina under non-storm conditions.

SLR (ft)	Structure Damage %			Perishable Content Damage %		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	0	0	0	0	0	0
4.9	28	35	43	37	43	65
6.6	33	40	48	43	47	65

Table 7-7: Potential damages for Newport Dunes Marina under 100-year storm conditions.

SLR (ft)	Structure Damage %			Perishable Content Damage %		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	5	10	17	5	18	28
4.9	33	40	48	43	47	65
6.6	43	53	60	50	70	90

7.1.4 Newport Dunes Resort

Minimal structural damage is projected for Newport Dunes Resort under 0.8-ft, 1.6-ft, and 4.9-ft SLR scenarios. Damage projections are also minimal under a 6.6-ft SLR scenario for non-storm conditions. Damage may occur under storm conditions with 6.6 ft of SLR, but all damage projections remain below 10% of structural value. The lack of damage projections within the resort area is largely due to the higher elevation of the structures as defined in the CoSMoS model. As discussed in Section 5.3, the CoSMoS model may not fully capture potential increased erosion and shoreline evolution within the interior of Newport Bay as SLR increases, and so may underestimate potential damages to resort structures under severe, long-term SLR scenarios.

Table 7-8: Potential damages for Newport Dunes Resort under non-storm conditions.

SLR (ft)	**Structure Damage %**			**Perishable Content Damage %**		
	Min	**Likely**	**Max**	**Min**	**Likely**	**Max**
0.8	0	0	0	0	0	0
1.6	0	0	0	0	0	0
4.9	0	0	0	0	0	0
6.6	0	0	0	0	0	0

Table 7-9: Potential damages for Newport Dunes Resort under 100-year storm conditions.

SLR (ft)	**Structure Damage %**			**Perishable Content Damage %**		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	0	0	0	0	0	0
4.9	0	0	0	0	0	0
6.6	0	5	9	0	5	8

7.1.5 Newport Aquatic Center

Structural damage projections for the Newport Aquatic Center are minimal under 0.8-ft, 1.6-ft, and 4.9-ft SLR scenarios. Minor structural damage is projected under non-storm conditions with 6.6 ft of SLR. Additional structural damage is projected under storm conditions with 6.6 ft of SLR, but likely damage remains limited to 10% of structural value.

Table 7-10: Potential damages for Newport Aquatic Center under non-storm conditions.

SLR (ft)	Structure Damage %			Perishable Content Damage %		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	0	0	0	0	0	0
4.9	0	0	0	0	0	0
6.6	0	5	9	0	5	8

Table 7-11: Potential damages for Newport Aquatic Center under 100-year storm conditions.

SLR (ft)	Structure Damage %			Perishable Content Damage %		
	Min	Likely	Max	Min	Likely	Max
0.8	0	0	0	0	0	0
1.6	0	0	0	0	0	0
4.9	0	0	0	0	0	0
6.6	5	10	17	5	18	28

7.2 Non-Market Value

Non-market value refers to those goods and services that cannot be directly measured through a market price when bought or sold. The non-market value of coastal resources is defined in terms of recreation value and ecosystem services such as water quality improvements in wetlands or the provision of ecological diversity within coral reefs. Non-market value loss within County of Orange tidelands is likely due to projected significant losses of sandy beach area within Newport Dunes and areas surrounding the Newport Aquatic Center as SLR increases.

Beaches provide non-market value in a number of ways, such as recreation and storm buffering capacity (California Department of Boating and Waterways, 2011). These values can be quantified in terms of willingness to pay, which corresponds to the amount that an individual consumer would be willing to pay to consume the good or use the associated service (Raheem et al., 2009). Non-market beach value can be broken down further in terms of use. Direct-use value consists of activities such as fishing or boating. Indirect-use refers to benefits such as shoreline protection or groundwater discharge, and non-use values include cultural or existence values that do not rely on use of or proximity to beaches.

Determination and quantification of non-market values associated with beaches remains challenging due to the inherent variability between locations. U.S. EPA estimates of the economic value of coastal ecosystems were used in this analysis to define beach value loss in a spatially explicit manner. U.S. EPA economic value estimates are based on a comprehensive review of past studies by economists, conservation biologists, and OPC staff to provide policy-relevant ecosystem service values for the California coastline. The study considered over 30 categories of ecosystem services in total and provides quantitative estimates of erosion regulation, recreation and ecotourism, and cultural heritage values associated with beach ecosystems (Table 7-12).

Table 7-12: Non-market values of California beach ecosystems in 2008 U.S. dollars (Raheem et al., 2009)

Non-Market Service Category	Service Flow Per Acre Per Year
Recreation and Ecotourism	$16,946
Erosion Regulation	$31,131
Cultural Heritage Values	$27
Total Value	$48,104

County of Orange tidelands contain approximately 17 acres of sandy beach area, resulting in a total annual service flow of approximately $975,000 based on EPA non-market service valuations and adjustments to 2019 dollars using Consumer Price Index values. Sea level rise is projected to significantly reduce this sandy beach area over time. Though CoSMoS shoreline change projections are not available within the study area, estimates of beach area loss can be made based on the landward extent of flood projections under non-storm conditions. Beach area loss estimates along with associated losses in service flow per year are presented in Table 7-13.

Table 7-13: SLR impacts on non-market values for tideland beach areas (2019 $US)

SLR Scenario	Loss of Beach Area (Acres)	Service Flow Loss Per Year
0.8ft	2.4	$136,000
1.6ft	3.7	$213,800
4.9ft	10.0	$572,000
6.6ft	13.4	$765,800

8. Adaptation

Changing coastal hazards due to SLR can be addressed in a number of different ways. Although numerous adaptation methods are available, adaptation measures generally fall into one of three categories: protection, accommodation, and retreat (Figure 8-1). In a SLR adaptation context, protection refers to those strategies that employ hard or soft engineered measures to defend existing resources from future SLR hazards without changes to the resource itself. Accommodation refers to strategies that involve modifying existing resources or designing new resources in a way that reduces the potential future impacts of SLR. Adaptation strategies centered on retreat focus on realignment, relocation, or removal of existing resources from identified high-hazard areas as well as limitations on the development of any new resources in hazardous areas. In practice, SLR adaptation often relies on hybrid approaches that combine elements from multiple categories over different spatial and temporal scales.

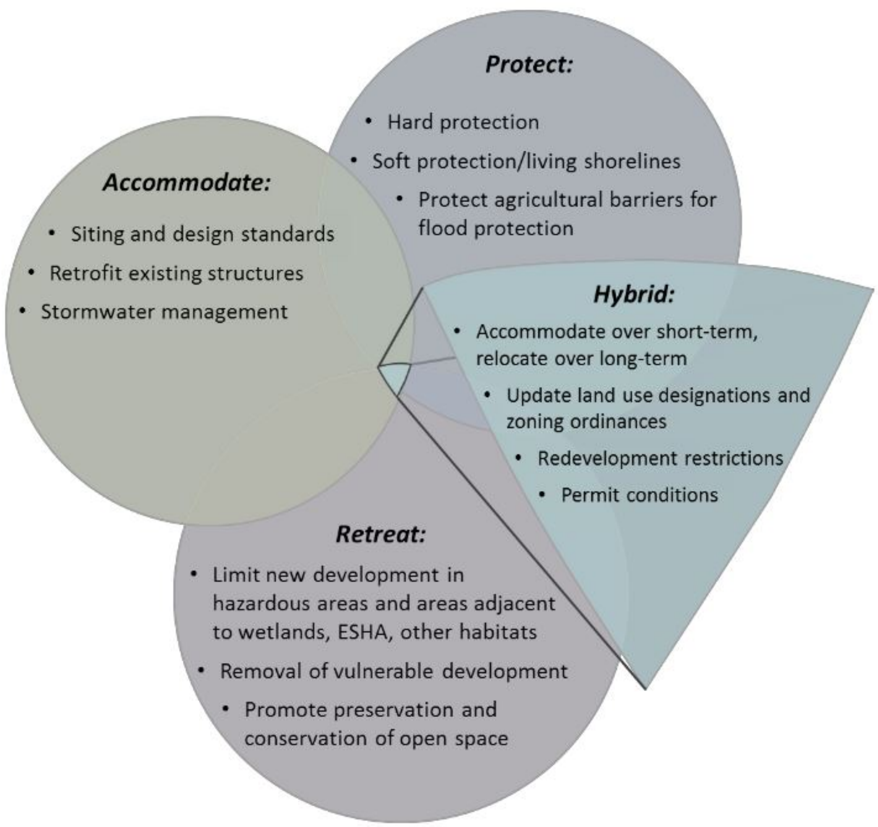


Figure 8-1: General SLR adaptation strategies and mechanisms (California Coastal Commission, 2015)

For this study, no individual adaptation strategy or category was considered a categorical "best" option for SLR adaptation planning within County of Orange tidelands. It is understood that a variety of adaptation strategies will likely be necessary to account for the different hazard vulnerabilities and coastal resources present at various locations within the study area, and that adaptation strategies will likely need to be adjusted over time as their relative effectiveness changes. The following sections describe potential SLR adaptation strategies for each resource category included in the vulnerability assessment. Certain strategies, such as protection for submerged tidelands, are excluded for certain resources, where appropriate, due to a lack of applicable adaptation measures.

8.1 Recreation and Coastal Access

8.1.1 Protection

Protection strategies can potentially be employed along coastal parking lots and access points within the study area to mitigate SLR impacts. Adaptation measures such as the construction of seawalls or other additional shoreline protection can be used to address projected flood impacts within resources such as Newport Sea Base and the Newport Dunes Marina parking lots. Shoreline protection may be installed permanently or deployed in the form of temporary flood barriers to protect key recreation and access resources during high-hazard conditions such as king tides or extreme storm events. Such measures are likely to be highly effective in addressing projected short-term SLR impacts but may become less feasible over time due to maintenance costs if tidal flooding becomes widespread.

Protection strategies are typically less appropriate for sandy beach areas. The fixed position of protection structures can exacerbate impacts of local erosion and lead to a gradual loss of beach width, a phenomenon known as “coastal squeeze” (Figure 8-2). Due to this potential for adverse impacts, any protection strategies implemented to address the vulnerability of recreation and coastal access resources should carefully consider siting in relation to sandy beach areas throughout County of Orange tidelands.

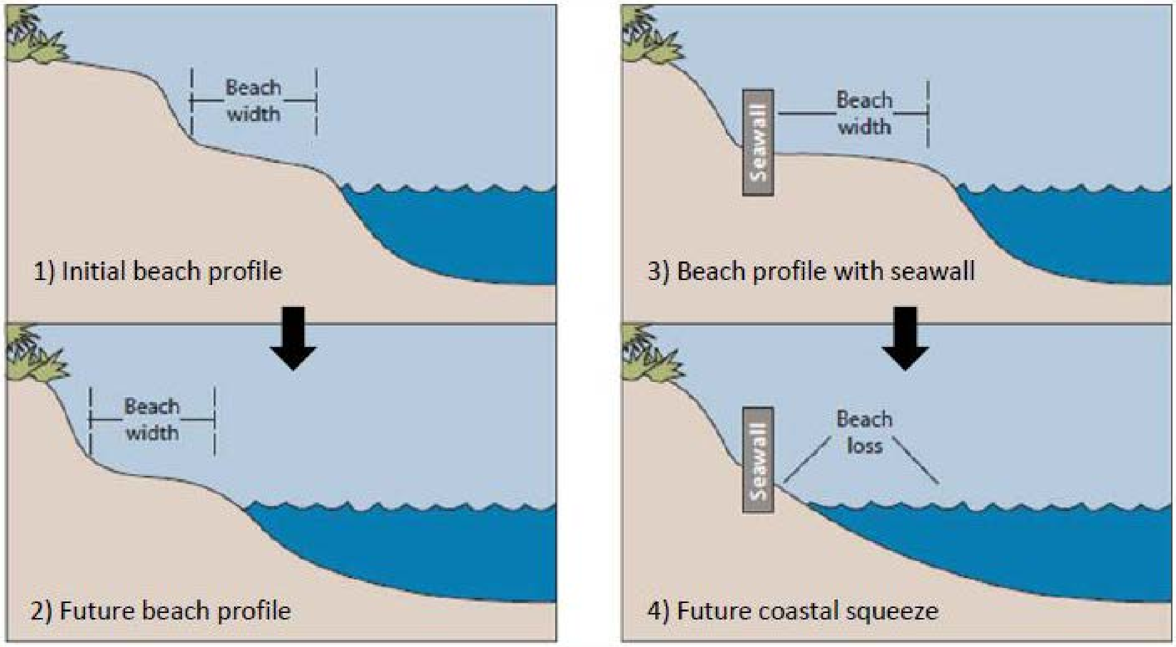


Figure 8-2: Potential coastal squeeze effect with the addition of hard shoreline protection (California Coastal Commission, 2018)

8.1.2 Accommodation

Recreation and coastal access resources can accommodate projected SLR impacts through elevation. Parking lots and other coastal access resources can be elevated through the use of fill or other methods in order to offset increased water elevations and maintain the current height of the shoreline relative to sea level. Beach area and height relative to sea level can also be maintained through periodic beach nourishment. Any planned elevation or beach nourishment event should be coordinated throughout the study area to avoid potential loss of aesthetic value or adverse impacts to other resources.

8.1.3 Retreat

Relocation or realignment of recreation and coastal access resources remain as options to address severe, long-term SLR impacts. Retreat measures are most feasible for resources that have open space located landward at higher elevations, such as the Newport Dunes Marina parking lot, where inland auxiliary parking and boat storage could potentially serve as relocation destinations. Sandy beach areas can also retreat landward through natural processes as water elevations rise if open space is made available (Figure 8-3). A conceptual example in the study area would be the realignment of the Newport Dunes campground or parking lots to allow surrounding beach areas to migrate inland over time. Though retreat measures are likely to be employed only in long-term, severe SLR scenarios, it is important that they are considered throughout the SLR adaptation planning process to avoid precluding any potential adaptation actions necessary to preserve critical recreational uses and access within the study area.

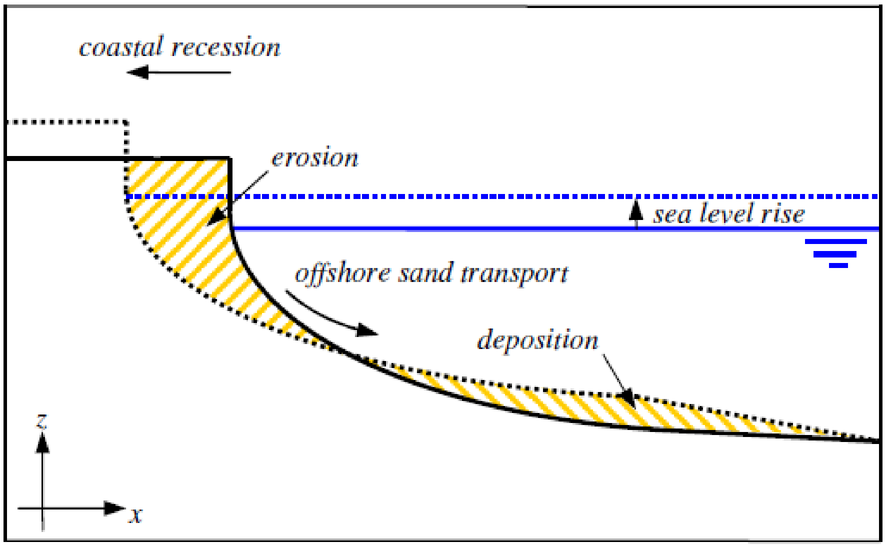


Figure 8-3: Natural beach area retreat with SLR

8.2 Submerged Tidelands and Waterways

8.2.1 Accommodation

Accommodation strategies for submerged tidelands and waterways are primarily based on maintaining current surface elevations relative to water levels. The feasibility of accommodation strategies for submerged tidelands and waterways within the study area is largely dependent on the rate of SLR compared to accretion rates and other ecological processes. If accretion rates within submerged areas are able to keep pace with SLR, these resources may be able to accommodate SLR with little outside intervention. Restoration of historic levels of sediment inputs through increased riverine discharge is likely to increase the potential for adaptation through natural processes and reduce the need for intervention. Natural rates of accretion can also be supplemented through sediment inputs if necessary using small sediment volumes spread over a wide area, referred to as thin-layer placement. Ecological monitoring will play a key role in the implementation of these adaptation strategies, including the identification of critical parameters that influence overall ecosystem resilience.

8.2.2 Retreat

SLR adaptation through retreat will depend on the availability of open space at higher elevations and the rate at which current submerged tideland resources are able to migrate over time. Again, there is potential for this process to occur organically, but it is also possible that the rate of ecological change will lag behind SLR, particularly under severe SLR scenarios. Additional measures can be implemented to facilitate landward migration if the rate of SLR does outpace ecological processes, including supplementing new habitat areas through planting of local tideland vegetation. Ecological monitoring will also be necessary for these adaptation measures in order to identify potential areas suitable for ecosystem retreat and track natural patterns of ecological migration over time.

8.3 Boating Infrastructure

8.3.1 Accommodation

Accommodation strategies for boating infrastructure, including any floating docks, access gangways, and guide piles, are linked to the structural design tolerance for high water levels. Limited effort may be required to preserve current use if boating infrastructure is currently designed to withstand water levels outside the normal tide range. If necessary, supporting structures such as dock anchors and guide piles can be elevated to accommodate projected water levels that fall outside of current design limits. A key consideration for these adaptation strategies is whether existing piles can remain in place or if new, higher piles will be needed to accommodate SLR over the planned infrastructure service life. Any dock redesign or replacement efforts within the study area provide critical opportunities to adjust the water elevation tolerance of boating infrastructure over time to match observed rates of SLR.

8.3.2 Retreat

Because boating infrastructure depends on proximity to the shoreline, retreat strategies may be necessary to account for potential shoreline migration over long-term SLR scenarios. This could potentially be accomplished through extension of existing infrastructure or replacement and relocation over time as docks reach the end of their service life, which typically ranges from 20 to30 years. Any landward relocation of boating infrastructure should be coordinated with other retreat or realignment base adaptation strategies throughout the study area.

8.4 Upland Development and Infrastructure

8.4.1 Protection

Multiple protection strategies are available for upland development and infrastructure within the study area. Much of the upland development in the immediate vicinity of the shoreline, such as Newport Dunes Marina, currently has some form of shoreline protection or stabilization in place, mainly consisting of bulkhead walls. This existing shoreline protection system can be augmented through retrofits or replacement of existing infrastructure to keep pace with increased height and frequency of flood events as SLR increases over time. Other upland development resources located further inland, including Newport Dunes Resort and the Newport Aquatic Center, have minimal shoreline protection in place. Structural protection such as revetments can be implemented to reduce SLR impacts to these structures, or nature-based strategies, such as living shorelines, can be employed to protect structures without further hardening existing shorelines (Figure 8-4). Temporary measures such as deployable flood barriers can also be used to address high-risk situations. Any adaptation strategies involving additional shoreline protection will need to consider potential adverse effects on surrounding resources such as beach areas, coastal access routes, and local ecosystems.

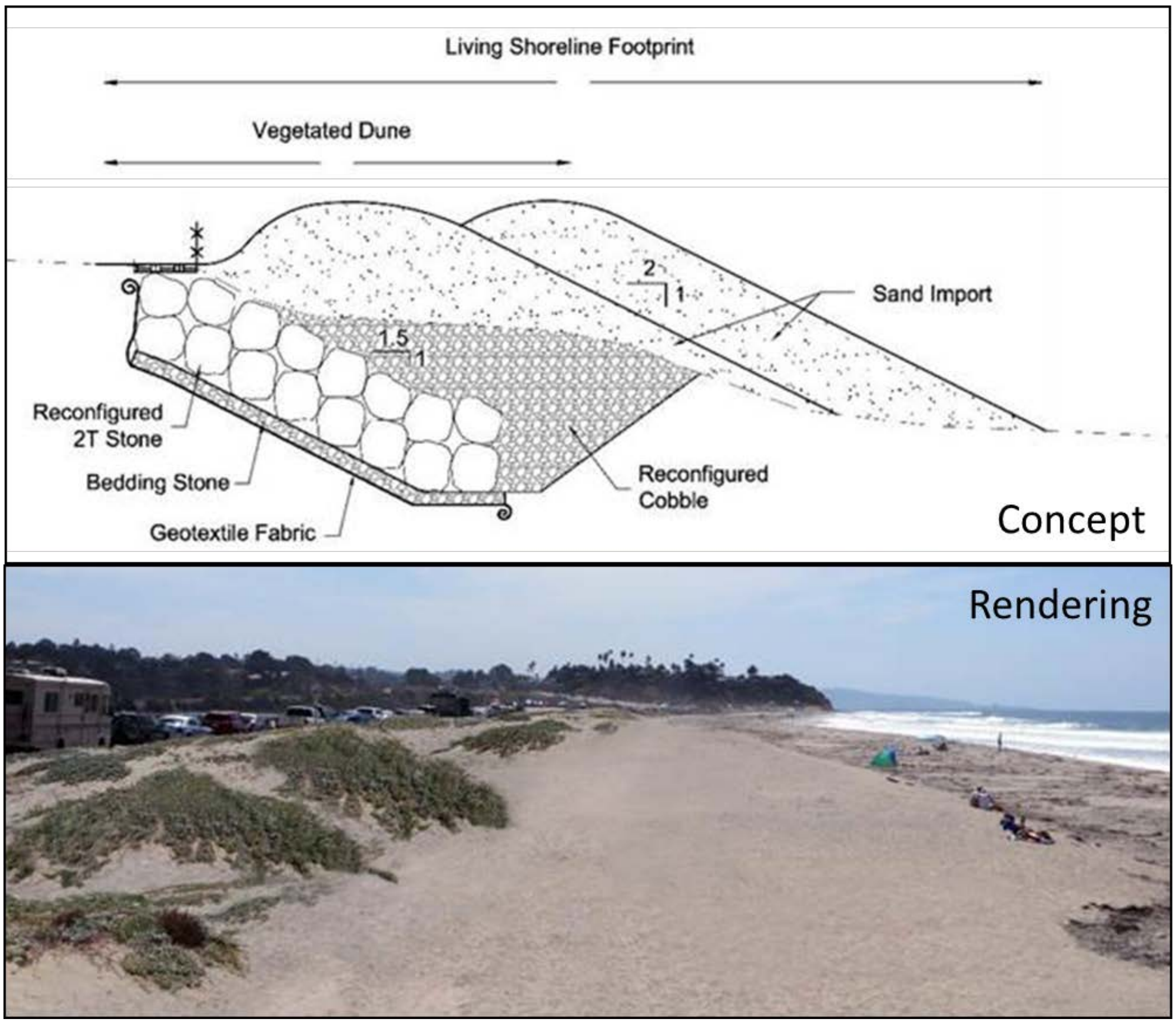


Figure 8-4: Living shoreline concept designed to protect inland areas from SLR

8.4.2 Accommodation

Coastal resources and structures can accommodate SLR hazards through both modification of existing development and design of new development. Accommodation strategies based on structural modification include actions such as structural elevation, retrofitting for flood resilience, and the use of flood resistant materials during construction (Figure 8-5). Accommodation strategies based on design can address SLR hazards by including potential relocation, redesign, or other form of adaptation in initial structural plans or by employing additional shoreline setbacks where possible. Temporary or permanent floodproofing retrofits and improvements to stormwater infrastructure can also be employed to reduce the impacts and recovery time following flood events.

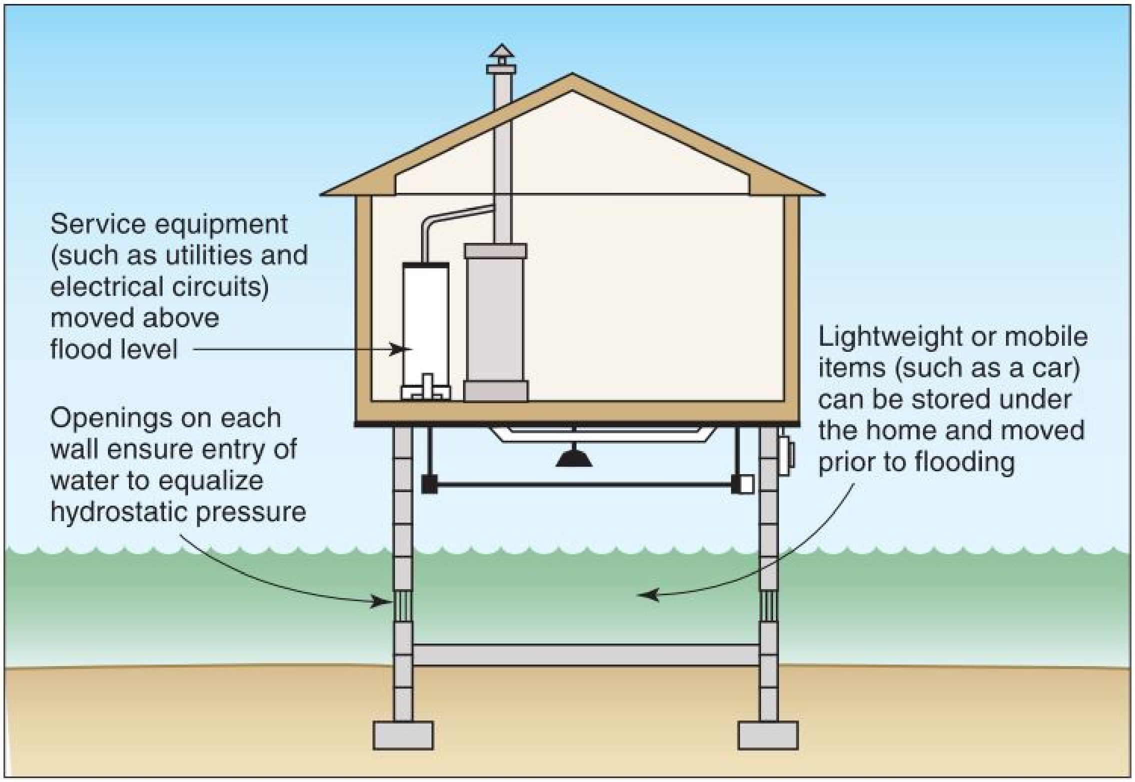


Figure 8-5: Example cross section of an elevated home using continuous foundation walls (FEMA, 2014)

8.4.3 Retreat

Directly removing or relocating vulnerable structures away from hazard areas represents an effective long-term form of SLR adaptation under high to extreme SLR scenarios. Retreat strategies can be employed for cases in which any feasible protection or accommodation strategies become insufficient to address coastal hazards. Although limited, there is some topographic variation within County of Orange tidelands that provides opportunity for the relocation of high-value, long-term upland development to higher ground as illustrated in Figure 8-6.

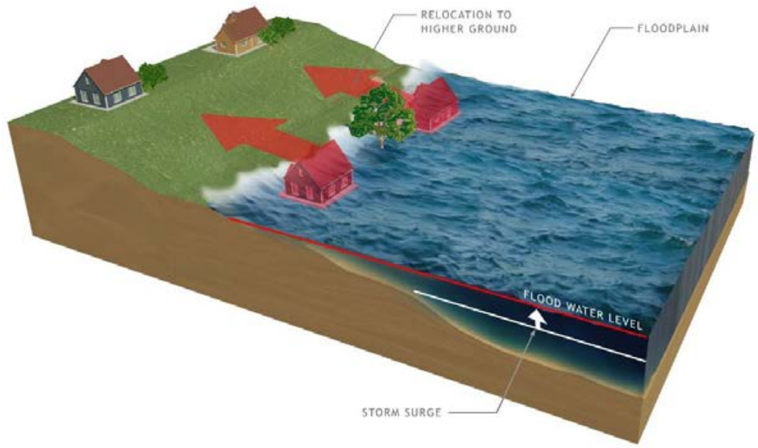


Figure 8-6: Conceptual example of retreat-based strategies for upland development

9. References

California Coastal Commission. (2015). California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits.

California Coastal Commission. (2018). Residential Adaptation Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs.

California Department of Boating and Waterways. (2011). The Economic Costs of Sea-Level Rise to California Beach Communities. San Francisco State University.

California Emergency Management Agency, & California Natural Resources Agency. (2012). California Adaptation Planning Guide: Planning for Adaptive Communities.

California Ocean Protection Council. (2018). State of California Sea-Level Rise Guidance: 2018 Update.

Erikson, L., Barnard, P., O'Neill, A., Vitousek, S., Limber, P., Foxgrover, A., Warrick, J. (2017). CoSMoS 3.0 Phase 2 Southern California Bight: Summary of data and methods. U.S. Geological Survey.

FEMA. (2014). Homeowner's Guide to Retrofitting: Six Ways to Protect Your Home From Flooding.

Griggs, G., Arvai, J., Cayan, D., Deconto, R., Fox, J., Fricker, H., Whiteman, E. (2017). Rising Seas in California: An Update on Sea-Level Rise Science. California Ocean Science Trust.

ICLEI. (2012). Sea Level Rise Adaptation Strategy for San Diego Bay.

IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Kopp, R. E., Horton, R. M., Little, C. M., Mitrovica, J. X., Oppenheimer, M., Rasmussen, D. J., Tebaldi, C. (2014). Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. Earth' s Future, 383–407. https://doi.org/10.1002/2014EF000239.Abstract

Nezlin, N. P., Kamer, K., Hyde, J., & Stein, E. D. (2009). Dissolved oxygen dynamics in a eutrophic estuary, Upper Newport Bay, California. Estuarine, Coastal and Shelf Science, 82(1).

Pollard, D., & Deconto, R. M. (2016). Contribution of Antarctica to past and future sea-level rise. Nature, 531. https://doi.org/10.1038/nature17145

Raheem, N., Talberth, J., Colt, S., Fleishman, E., Swedeen, P., Boyle, K. J., Boumans, R. M. (2009). The Economic Value of Coastal Ecosystems in California.

Rosencranz, J. A., Ganju, N. K., Ambrose, R. F., Brosnahan, S. M., Dickhudt, P. J., Guntenspergen, G. R., Thorne, K. M. (2016). Balanced Sediment Fluxes in

Southern California ' s Mediterranean-Climate Zone Salt Marshes. Estuaries and Coasts, 1035–1049. https://doi.org/10.1007/s12237-015-0056-y

Seapy, R. (1981). Structure, distribution, and seasonal dynamics of the benthic community in the Upper Newport Bay, California. California Department of Fish and Game Marine Resources Technical Report NO.46.

Snover, A., Whitley Binder, L., Lopez, J., Willmott, E., Kay, J., Howell, D., & Simmonds, J. (2007). Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. ICLEI - Local Governments for Sustainability.

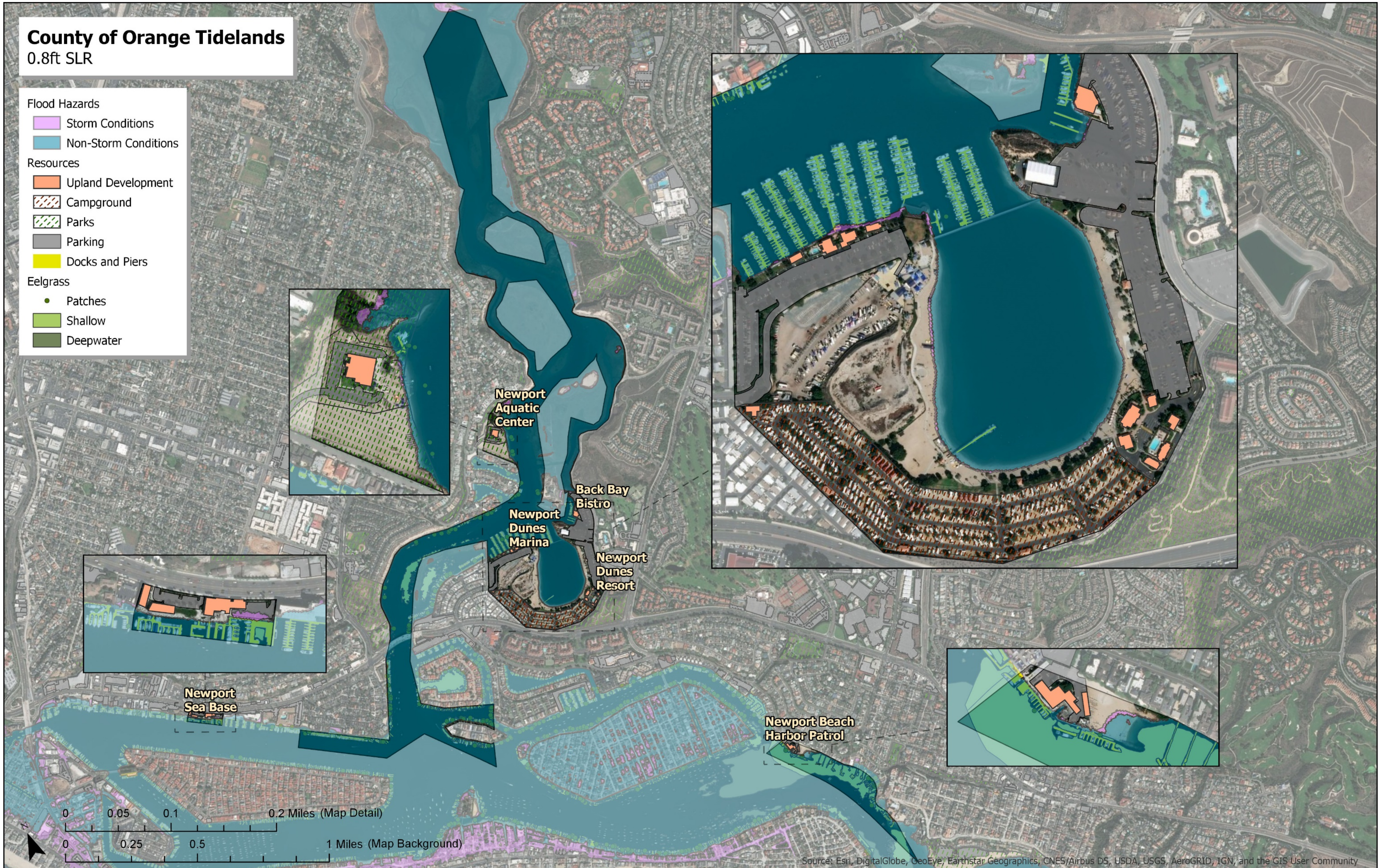
Stagg, C. L., Cormier, N., & Conner, W. H. (2016). Processes Contributing to Resilience of Coastal Wetlands to Sea-Level Rise.

Sweet, W., Kopp, R., Weaver, C., Obeysekera, J., Horton, R., Thieler, R., & Zervas, C. (2017). Global and Regional Sea Level Rise for the United States. NOAA Technical Report NOS CO-OPS 083, (January).

U.S. Army Corps of Engineers. (2015a). North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, Main Report.

U.S. Army Corps of Engineers. (2015b). North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, Physical Depth Damage Function Summary Report.

10. Hazard Map Appendix


County of Orange Tidelands
0.8ft SLR
Flood Hazards
Storm Conditions
Non-Storm Conditions
Resources
Upland Development
Campground
Parks
Parking
Docks and Piers
Eelgrass
Patches
Shallow
Deepwater
Newport Aquatic Center
Back Bay Bistro
Newport Dunes Marina
Newport Dunes Resort
Newport Sea Base
Newport Beach Harbor Patrol
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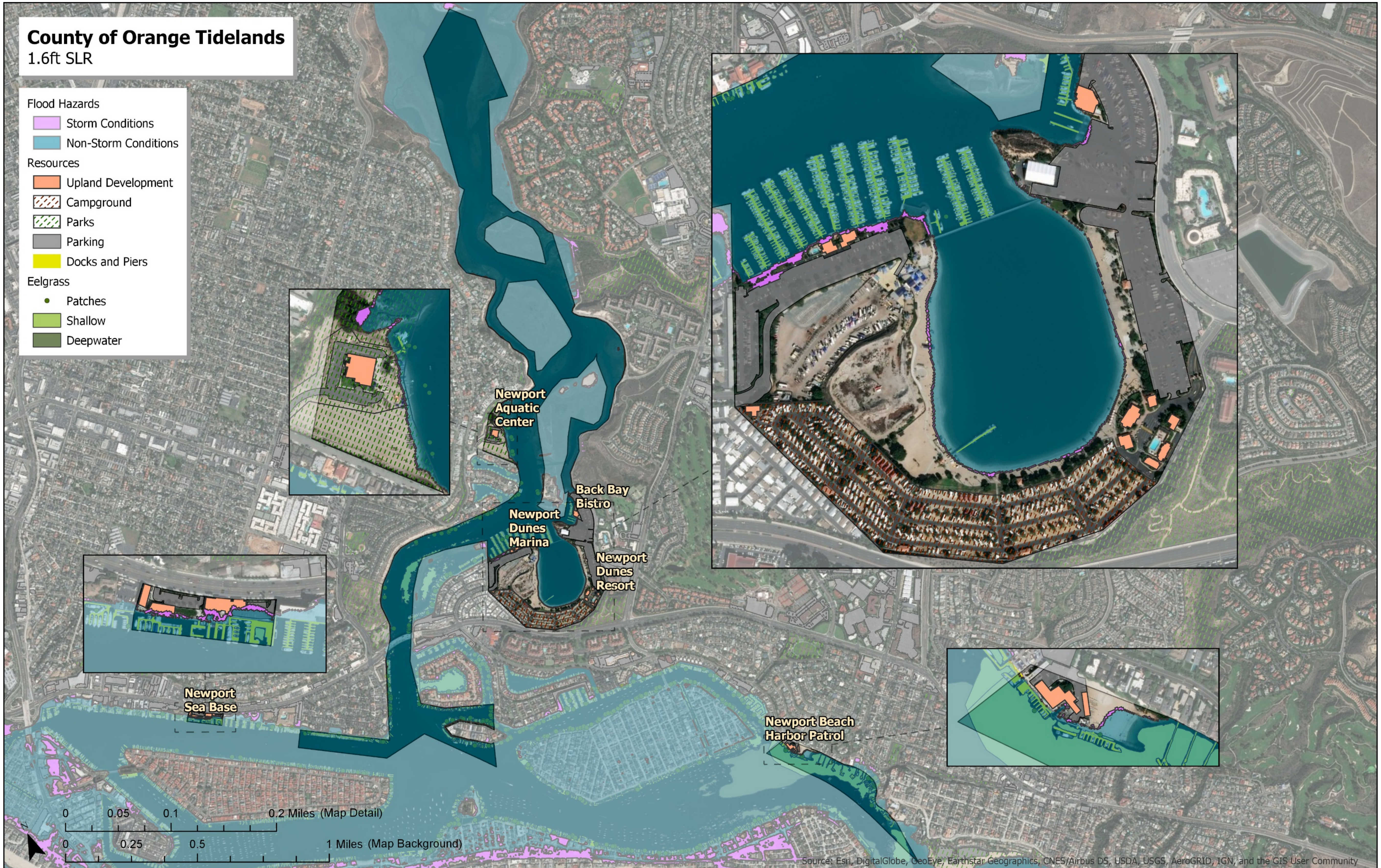
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


County of Orange Tidelands
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Flood Hazards
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Upland Development
Campground
Parks
Parking
Docks and Piers
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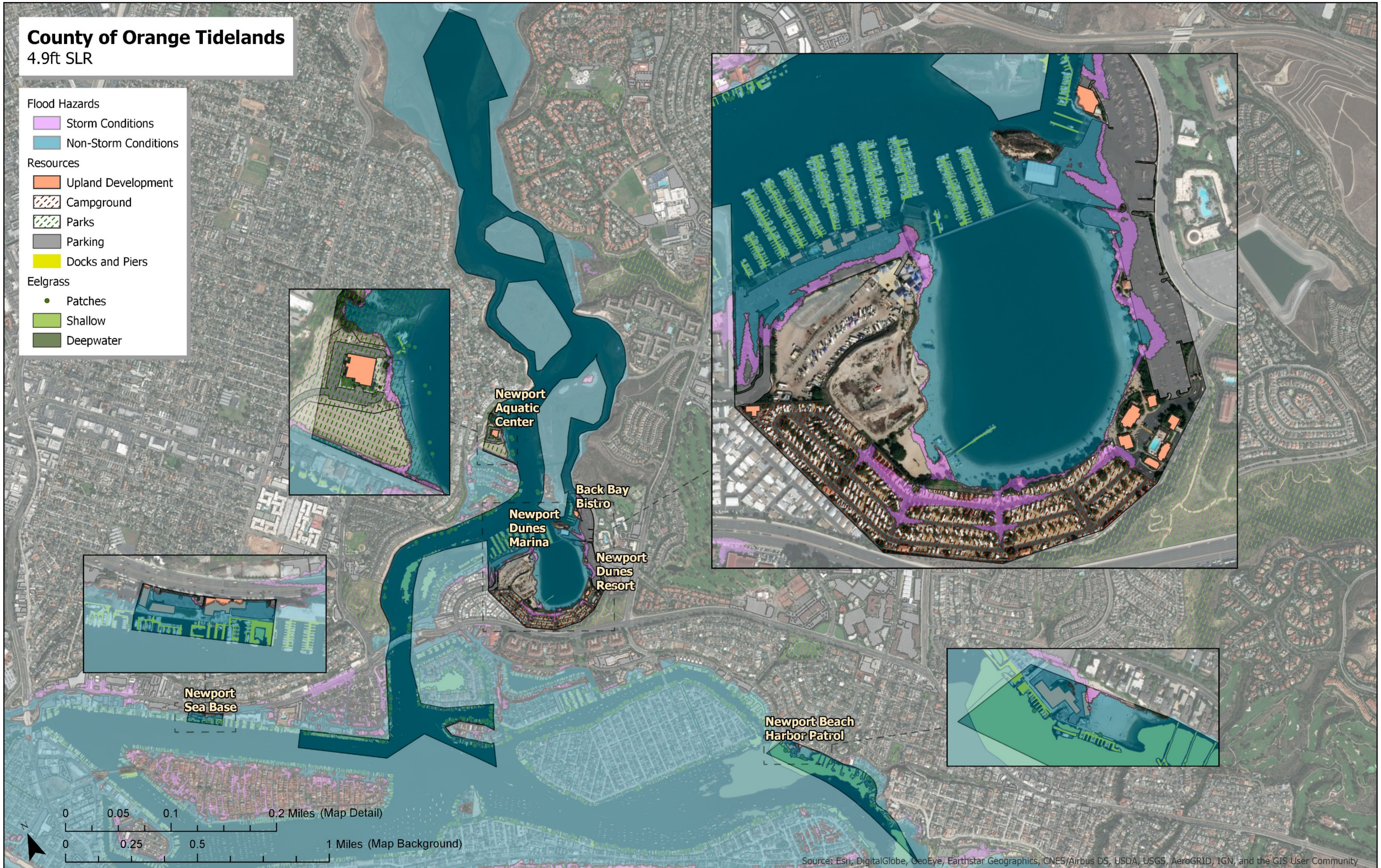
County of Orange Tidelands
4.9ft SLR
Flood Hazards
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Non-Storm Conditions
Resources
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Campground
Parks
Parking
Docks and Piers
Eelgrass
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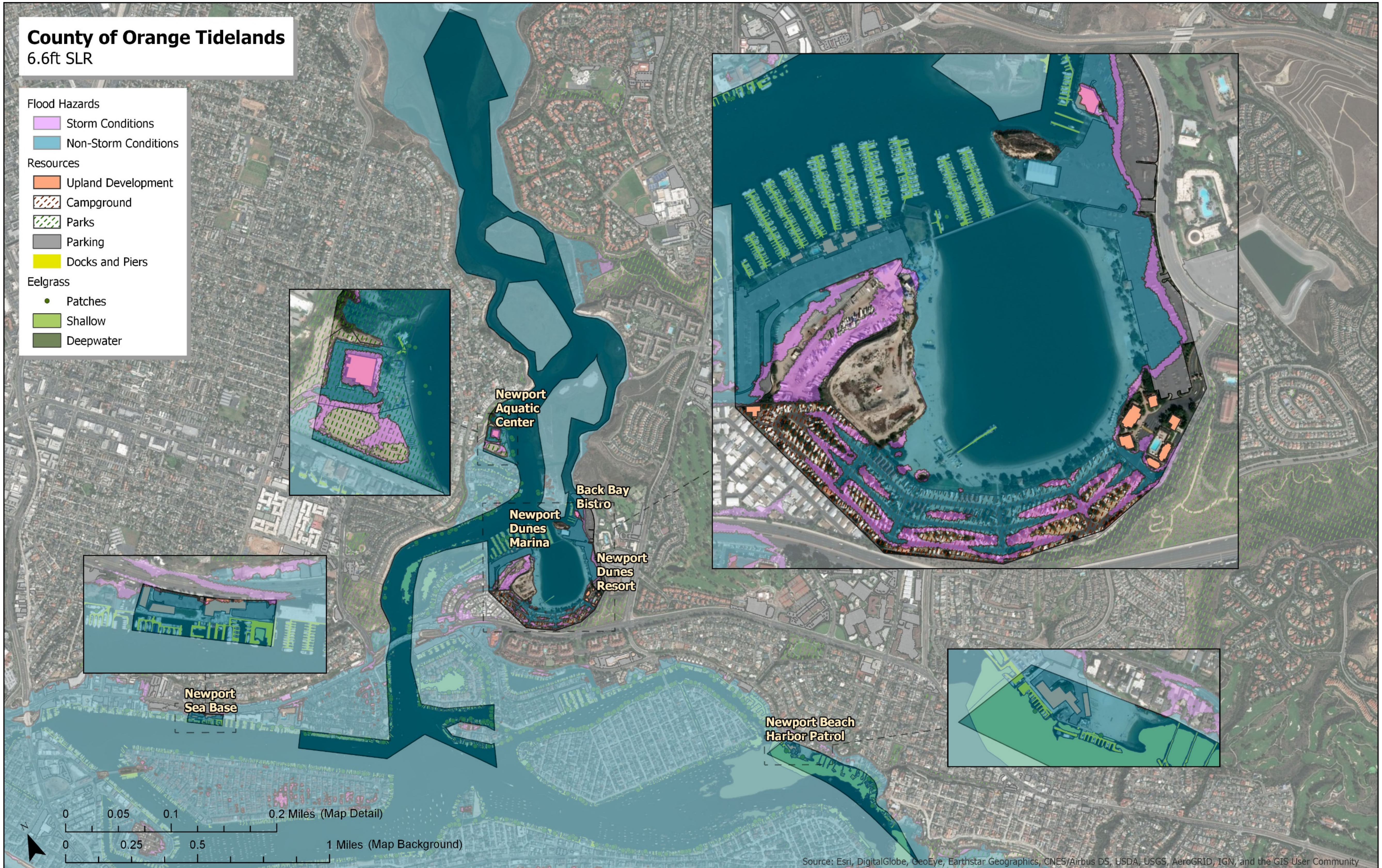
County of Orange Tidelands
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