City of San Clemente
Sea Level Rise Vulnerability Assessment

Prepared with assistance from:

moffatt & nichol

October 2019

Funded by CCC Grant LCP-16-11

CALIFORNIA COASTAL COMMISSION

Table of Contents

TABLE OF TABLES

TABLE OF FIGURES

Acronyms and Abbreviations

AMSL	Above Mean Sea Level
CCC	California Coastal Commission
CCSTWS-SD	Coast of California Storm and Tidal Wave Study for the San Diego Region
CDIP	Coastal Data Information Program
cm	centimeter
COAST	Coastal One-line Assimilated Simulation Tool
CoSMoS	Coastal Storm Modeling System (published by USGS)
ft	feet
H++	Extreme SLR scenario due to rapid Antarctic ice sheet mass loss (Sweet et al, 2017)
HAPC	habitat areas of particular concern
in	inch
IP	Implementation Plan
LCP	Local Coastal Program
LOSSAN	Los Angeles to San Diego Rail Corridor
LUP	Land Use Plan
m	Meter
M&N	Moffatt & Nichol
MHHW	mean higher high water
MLLW	mean lower low water
NAVD 88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
OCCRSMP	Orange County Coastal Regional Sediment Management Plan
OCOF	Our Coast, Our Future
OCTA	Orange County Transportation Authority
OPC	Ocean Protection Council
SANDAG	San Diego Association of Governments
SCRRA	Southern California Regional Rail Authority
SLR	Sea Level Rise
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VA	Vulnerability Assessment
yr	year

Disclaimer

It is understood that estimating and projecting future weather, tidal, ocean and on-shore conditions and their impacts upon existing or contemplated developments or resources is difficult, complex and based on variable assumptions, and further, is impacted by factors potentially beyond the Consultant's ability to predict or control. Accordingly, any estimates, forecasts reviews or assessments provided as part of the Services are presented solely on the basis of the assumptions accompanying the estimates, forecasts, reviews and assessments, and subject to the information or data utilized at the time of this Project. As such, Consultant makes no warranty that the mitigation measures will be adequate to protect against actual climate events. In addition, to the extent Consultant utilizes materials provided by the Client or third parties, or material that is generally available, Consultant is entitled to rely upon any such information concerning the Project, except to the extent it is explicitly provided that Consultant will independently verify the accuracy or completeness of such materials or information.

Produced by:

Moffatt & Nichol
4225 E Conant Street
Long Beach, CA 90806
(562) 426-9551
www.moffattnichol.com

Executive Summary

The purpose of this Sea Level Rise Vulnerability Assessment (SLRVA or Study) is to identify areas and resources in the City that may be vulnerable to rising seas in the future, so the City may begin to consider ways to improve and enhance coastal resiliency for the long term. This SLRVA identifies several potential impacts on coastal resources in San Clemente for SLR scenarios higher than 0.8 feet (25 cm).

A resource's vulnerability to SLR is a product of:

- Exposure to coastal hazards (shoreline erosion, flooding and inundation);
- Sensitivity to coastal hazards (potential for damage or loss of function); and,
- Adaptive capacity (ability to restore function or avoid damage).

This Study was funded in part by the California Coastal Commission (CCC) grant LCP-16-11 awarded to the City of San Clemente (City) to support certification of the City's Local Coastal Program (LCP) Land Use Plan (LUP), and the development of an LCP Implementation Plan (IP) with the goal of achieving a certified LCP. A portion of the grant budget was allocated for this SLRVA to inform policies and adaptation strategies contained in the LCP. Key questions that were the focus of this study and related findings are as follows:

What are the hazards associated with sea level rise for San Clemente?

Shoreline erosion is expected to accelerate with sea level rise and will likely be the most significant hazard impacting coastal resources in San Clemente due to "coastal squeeze." Coastal squeeze can be defined as the process by which sea level dependent physical, cultural, or biological areas are pushed landward with SLR but are prevented from natural landward migration due to a protected or non-erodible structure. For San Clemente, the dry beach and intertidal zone (and assets dependent on these areas) in front of the railroad revetment are at risk of permanent loss due to "coastal squeeze" throughout the study area as illustrated in Figure 1.

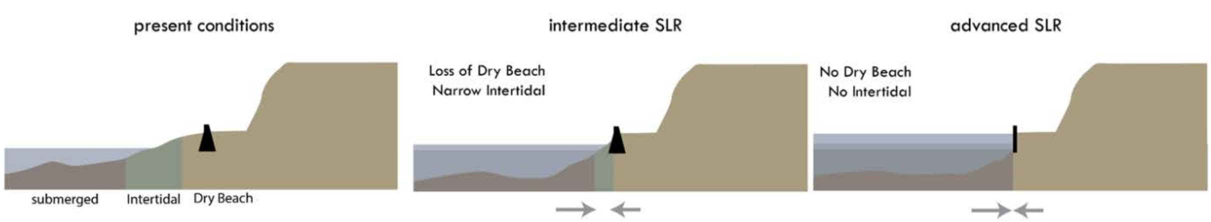


Figure 1: Illustration of Coastal Squeeze in front of a Non-erodible Structure

What magnitudes of sea level rise matter for San Clemente and what resources are at risk?

Due to the ongoing trend of shoreline erosion affecting San Clemente and many other jurisdictions in the region any amount of SLR will exacerbate the impacts from a long-term reduction in littoral sediment delivered to the coastline south of Dana Point as described in Section 2.1. As sea level rise increases over longer time horizons, there are notable thresholds which result in progressively greater impacts that will require progressively greater action to mitigate. Below are key thresholds identified for each sea level rise scenario evaluated and the resources most at risk to coastal hazards.

- **0.8 ft (25 cm) SLR:** Existing sandy beaches erode and lose about half their width, some areas (North Beach and Mariposa Point) erode completely to the railroad impacting coastal access, recreation and the environmental resources seaward of the railroad. Structures on the beach, including the Pier and Marine Safety Building, are vulnerable to more frequent storm related flooding, damage, erosion, scour, and undermining.
- **3.3 ft (100 cm) SLR:** Most sandy beaches are eroded up to the railroad, small beaches may exist seasonally and at low tide. Shoreline erosion projections indicate this may be close to a threshold point for the railroad corridor as the railroad would be subject to repeated wave attack and flooding during high tides and storm events.
- **4.9 ft (150 cm) SLR:** This scenario assumed the railroad and revetment has been relocated and removed from service in its current location. Under this assumption shoreline retreat could reach the coastal bluffs. Parcels atop the bluff would be vulnerable to bluff failures resulting from increased wave action at the toe in the absence of the protective railroad revetment, or some other form of adaptation.

When could these scenarios happen and how do we plan for them?

The California Coastal Commission presently recognizes the *State of California Sea Level Rise Guidance* (OPC 2018), released in March 2018 by the Ocean Protection Council (OPC), as the best available science on sea level rise along the coast of California. The OPC (2018) Guidance uses a probabilistic approach to generate a range of SLR projections at a given time horizon.

For the 2050 time horizon the “likely range” of SLR is between 0.7 to 1.2 feet which means there is a 66% probability that SLR will fall within this range. The guidance document also acknowledges the potential for less probable scenarios that result in higher amounts of SLR. For example, the document indicates there is a 0.5% chance SLR reaches 2 feet by 2050. In other words, the 0.8 foot SLR scenario would most likely occur in the 2040-2050 timeframe, but there is a very slight chance it could occur in 2030.

The likely range of SLR at the 2100 time horizon is 1.8 – 3.6 feet, but there is a 0.5% chance SLR reaches 7.1 feet. The range of projections at these longer time horizons increases significantly due to uncertainties associated with future emissions, the physical processes affecting how the Antarctic ice sheets may respond to such scenarios, and many other factors. Based on the OPC projections a 3.3 foot SLR scenario would most likely occur near the end of this century, but there is a very slight chance it could occur by 2070. The 4.9 foot SLR scenario would most likely occur in the 2130-2140 timeframe, but there is a very slight chance it could occur in the 2080-2090 timeframe.

Coastal Resiliency Building and Adaptation Planning in San Clemente

This Study identifies the City's sea level rise related vulnerabilities from coastal hazards and introduces a range of potential adaptation strategies. The City will also prepare a companion Coastal Resiliency Plan which will contain a discussion of potential adaptation strategies that the City can implement over time to improve coastal resiliency. The Coastal Resiliency Plan will identify more focused municipal actions, regional actions, coordination activities, and various sea level rise adaptation strategies for various areas in the City.

Most cities will likely consider a range of options in their adaptation strategy toolbox. Keeping a range of options on the table helps to ensure that the City retains maximum flexibility in determining how best to carry out its long-term vision for its community. Considering a range of options is also prudent as the understanding of climate science continues to improve in terms of both its predictive capabilities and its ability to identify the most probabilistic local scenarios. Monitoring of sea level rise is an important component of adaptation planning and future updates to the LCP will reflect updated climate science, predictions, scenario probabilities and possibly a wider range of adaptation strategies to consider.

Adaptation to climate change involves a range of small and large adjustments to natural and/or human systems that occur in response to already experienced or anticipated climate change impacts. Adaptation planning involves a wide range of policy, programmatic and project-level measures that can be implemented in advance of the potential impacts, or reactively, depending on the degree of preparedness and risk tolerance. Good adaptation planning should enhance community resilience to hazards and natural disasters and should stem from full disclosure and a solid understanding of the City's specific risks, the projected timing of impacts and the physical processes responsible for causing the risk, now and in the future.

While the City has a long history of addressing coastal hazards, this is the first focused endeavor by the City to identify possible responses to climate change impacts at the coast, including adaptation strategies based on preparedness, avoidance, and/or protection from the risks projected to occur over time. Ideally, this planning will lead to dedicated funding to protect the community and natural resources, which make San Clemente such a desirable location to live, work, play and visit.

Adaptation planning requires consideration of the various vulnerabilities and taking effective and timely action to alleviate the anticipated range of consequences. The City is currently working with the USACE to implement a long-term program to address shoreline erosion and this is anticipated to remain one of the primary adaptation tools utilized by the City to maintain its shoreline and public beaches.

The extent of work completed for this study is based on the budget allocated in the Round 3 LCP Planning Grant work program approved by the CCC and the City. This SLRVA leverages existing coastal engineering reports and sea level rise hazard information to the extent possible. The Study was guided by the CCC's Sea Level Rise Policy Guidance document and Safeguarding California: Reducing Climate Risk (Natural Resources Agency, 2014).

This SLRVA includes the following tasks to satisfy the CCC's requirements to incorporate SLR planning into the LCP update process:

a. Evaluation of storm and non-storm scenarios using data from the Coastal Storm Modeling System (CoSMoS 3.0) published by the United States Geological Survey (USGS).
b. Estimation of anticipated changes in beach width under future SLR scenarios.
c. Assessment of SLR vulnerabilities identifying existing infrastructure and public and private developments potentially at risk due to rising seas.
d. Evaluation of SLR-related effects on existing and planned segments of the California Coastal Trail in the City.
e. Qualitative evaluation of the feasibility and effectiveness of sediment management and beach nourishment using all applicable and relevant data including the City's Coastal Storm Damage Reduction Project (USACE, 2012).

The scope of this SLRVA was limited to the data provided to M&N by the City and other information available at the time of the Study. No additional numerical modeling, hazard analysis, collection or mapping of assets, infrastructure or coastal resources were performed as part of this scope of services.

1. Introduction and Approach

The City of San Clemente (City), known as the "Spanish Village by the Sea," is a quintessential southern California beach town. Despite having relatively narrow bluff backed beaches, the coastline is very accessible and offers a wide variety of scenic, cultural and recreational opportunities for locals and visitors. Much of the community's identity and tourism draw are due to the vibrant beach culture and variety of coastal assets from North Beach to the Pier Bowl to more secluded beaches in the southern part of the City.

Recent sea level rise (SLR) science and coastal hazards projections indicate that valuable coastal resources (or sectors) like those in the City, and elsewhere along the California coastline, will be exposed to more intense coastal hazards like beach erosion, coastal flooding, and inundation in the future. This study is based on SLR projections released by the Ocean Protection Council (OPC) report *State of California Sea Level Rise Guidance (OPC, 2018)*. The potential effects of SLR on existing coastal hazards such as beach and bluff erosion and storm related flooding were evaluated using results of the Coastal Storm Modeling System (CoSMoS), a multi-agency effort led by the United States Geological Survey (USGS).

1.1 Study Approach

The purpose of this SLRVA is to understand how rising seas could impact coastal resources in the City. The term "coastal resource" is used to describe both natural and manmade features that provide a benefit to the City, its residents, businesses and visitors. The term "asset" is used to describe a specific resource or facility being evaluated. Key questions that guide the vulnerability assessment are illustrated in Figure 2. The first step is to identify how coastal hazards may change with various increments of SLR. By comparing predicted hazard zones with coastal resources in the City one can understand based on magnitudes of sea level rise, which effects could be significant in the City. The vulnerability of an individual asset or resource is dependent on three factors:

- **Exposure** refers to the type, duration and frequency of coastal hazard a resource is subject to under a given sea level rise scenario. A resource that experiences daily tidal, wave or water level fluctuations would be considered to have a greater SLR exposure risk than a resource that only experiences some minor flooding during an extreme wave or storm event.
- **Sensitivity** is the degree to which a resource is impaired by exposure to a coastal hazard. For example, a restroom with a shallow foundation would be more sensitive to undermining from erosion than a deepened pile supported structure such as the City's Municipal Pier.
- **Adaptive Capacity** is the ability of a resource to adapt to changing coastal hazards. Beaches function as a natural buffer between the ocean waves and upland areas and have the ability to adapt due to sand transport (and principles of dynamic equilibrium) if sufficient sand exists in the littoral cell and landward space is available for this migration. Infrastructure typically has a low inherent adaptive capacity because increased coastal hazards can exceed the design capacity requiring improvements to maintain the asset.

The SLRVA informs the LCP by outlining potential consequences and key SLR thresholds for the City. This information may be used by the City to support policies and adaptation strategy development for the LCPCP to improve coastal resiliency.

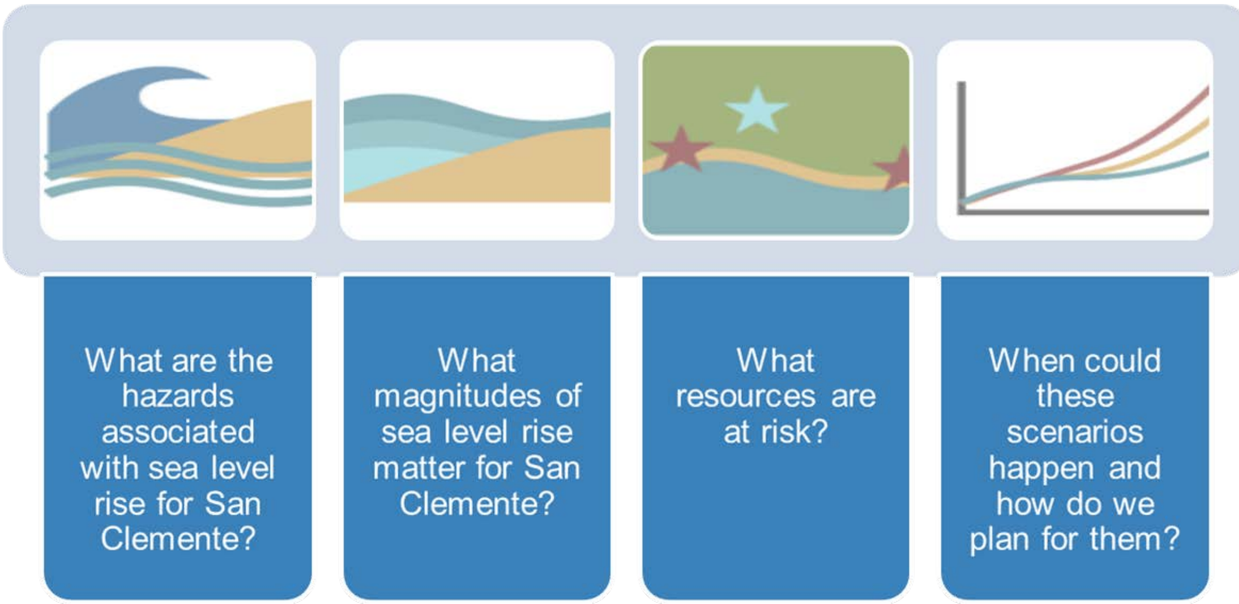


Figure 2: Key Questions for a Vulnerability Assessment

1.2 Existing Coastal Setting

The City is currently exposed to a variety of coastal hazards including beach erosion, bluff erosion and coastal flooding (Griggs et al., 2005). Coastal processes are described in more detail in Section 2 of this Study. The City coastline consists of a narrow sandy beach backed by coastal bluffs. The City is located in the northernmost section of the Oceanside Littoral Cell, which spans from Dana Point in the north to La Jolla in the south. The San Juan Creek is the primary sediment source for the San Clemente reach of this littoral cell (USACE, 1991). During dry periods, the lack of fluvial (riverine) sediment input often results in shrinking dry sand beach (Coastal Environments, 2014). Opportunistic beach nourishment has been performed in 2017 to help protect existing beach facilities and provide continued public recreational opportunities for residents and visitors to the City. The City and the U.S. Army Corps of Engineers (USACE) along with State Parks are jointly developing a long-term beach nourishment program to reduce coastal storm damage, improve public safety and support recreational opportunities.

1.3 Study Area

The description of the study area is based on the Certified LCP Land Use Plan (LUP) dated February 2018 and includes the stretch of coastline from the City's boundary with Dana Point in the north to the boundary with Marine Corps Base Camp Pendleton in the south. The Capistrano Shores mobile home park community is characterized in the LUP Policy GEN-10 as subject to the previously Certified LUP (1996) and is therefore excluded from the SLRVA study area.

The coastline of San Clemente has been sub-divided into three reaches for presentation and discussion of the SLR hazards for the purposes of this study. The North and Central Reaches are shown in the top portion of Figure 3. The south reach is shown in the lower portion of Figure 3. These study areas are described below:

- *North Reach – The north reach extends from the northern City boundary with Dana Point to the Linda Lane beach access and consists of the North Beach recreational area and LOSSAN railroad revetment to the south. Capistrano Shores mobile home park community is excluded from the study area. North Beach varies in width from 15-100 feet (from 2017 aerial imagery) and is popular for recreational activities. The beach area is subject to seasonal erosion that has recently threatened the restroom building and volleyball courts.*
- *Central Reach – This reach extends from Linda Lane to T-Street and includes the main beaches around the Pier and other facilities like the Marine Safety Building and restaurants at the base of the Pier. The Pier structure helps maintain a wider beach that varies from 80 to 130 feet in this area (from 2017 aerial imagery). T-street is a popular surfing area and the nearshore reef helps dissipate storm wave energy and stabilize the sandy beach in this area (USACE, 2012).*
- *South Reach – The south reach extends from just south of T-Street at the Boca Del Canon beach access point to the southern City boundary. There is little development seaward of the LOSSAN Railroad Corridor along this reach. The beach width varies from 80 to 200 feet (from 2017 aerial imagery) with primary coastal access points at Avenida Calafia and San Clemente State Beach Park.*

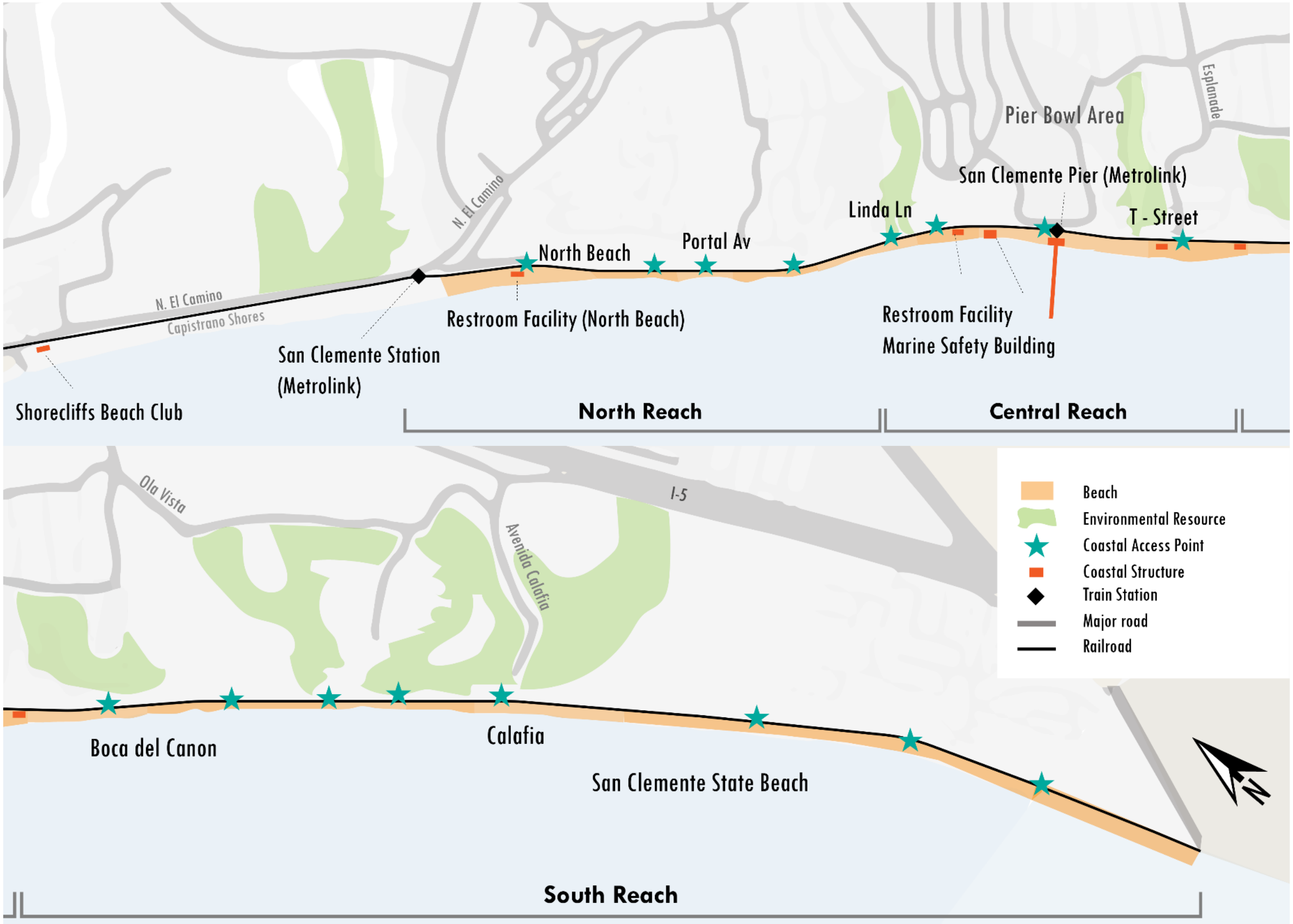


Figure 3: Study Reaches

1.4 Coastal Resources

The coastal resources described in this SLRVA come from those outlined in the San Clemente Centennial General Plan (2014), Local Coastal Program (LCP) Land Use Plan (LUP) (2018) with additional assets determined through analysis of data provided by the City and other regional and federal agencies. The inventory of coastal resources and specific assets analyzed in this study are summarized in Table 1.

Table 1: Coastal Resource Inventory in San Clemente

Resource Category	Specific Assets	Data Source
Transportation	▪ LOSSAN Rail Corridor ▪ Most roads in the City (except those noted below) are above an elevation of ~25 ft NAVD and setback from the potential SLR affected areas and therefore are a low concern for SLR impacts ▪ Lower lying roads are found at El Camino Real in the North Reach, in the San Clemente Pier Bowl area, Boca del Canon and near Calafia State Park ▪ Parking lots, traffic signals and associated infrastructure located west of El Camino Real at North Beach	OCTA, AMTRAK San Joaquin TCA City of San Clemente
Beaches and Public Trust Resources	▪ North Beach, Pier Bowl, Avenida Calafia, San Clemente State Beach	Aerial imagery from Google Earth
Public Access	▪ 19 Coastal Access Points as defined by the California Coastal Commission ▪ Coastal Trail (currently constructed segment)	California Coastal Commission City of San Clemente
Coastal Services & Amenities Located on the Beach	▪ Marine Safety Headquarters Building ▪ Restrooms (North Beach, Linda Ln., the pier, T-street, Boca) ▪ San Clemente Municipal Pier ▪ Sports courts/Playgrounds ▪ Shorecliffs beach club (private) ▪ Public Beach Fire pits which vary in number and location seasonally/annually and currently total 12 in 2019	City of San Clemente
Water Infrastructure	▪ Recycled, storm, and potable water lines	City of San Clemente
Historic Buildings	▪ Ole Hanson Beach Club ▪ Casa Romantica	National Register of Historic Places
Environmental Resources	▪ Coastal Canyons ▪ Sandy Beach Habitat ▪ Subtidal habitat ▪ Bluffs	San Clemente Centennial General Plan, Local Coastal Program Land Use Plan, and USACE

1.5 LOSSAN Rail Corridor

A prominent feature of the San Clemente coastline is the existing LOSSAN (Los Angeles to San Diego) Rail Corridor, which follows an alignment along the toe of the coastal bluff and is protected by a revetment in many locations. The segment along San Clemente's coastline is owned by the Orange County Transportation Authority (OCTA). The Southern California Regional Rail Authority (SCRRA) forecasts 58 trains carrying 17,760 passengers per weekday for the Year 2020. Amtrak forecasts 32 trains per day carrying a total of 5,760,000 annual passengers. In addition, there are currently6 freight trains per day utilizing this rail corridor (USACE, 2012). The existing rail corridor is one of the U.S. Department of Defense's designated Strategic Rail Corridors (USACE, 2012) in part because it provides direct rail access to, and through, Marine Corps Base Camp Pendleton.

The railroad sits at elevations ranging from 20-25 feet NAVD88[1] (17.5-22.5 feet above mean sea level) within the City. The lowest points are located at the San Clemente Station, San Clemente Municipal Pier, and San Clemente State Beach Park and are at an approximately elevation of 5-20' AMSL. The highest points along the alignment are when the railroad lies closest to the bluff in the north and southern portions of the city. The railroad is protected by a non-engineered revetment consisting of rock ballast placed on the seaward side of the railroad (USACE, 2012) along most, but not all, of its alignment in the City as shown in Figure 4 through Figure 8. Areas of the railroad within the Central Reach (See Figure 2) have no existing shoreline protection in place.

In some locations, particularly along the North Reach, the active shoreline abuts the railroad revetment limiting beach access and recreational opportunities as there is no dry sand beach. Coastal hazards and the effects of SLR on coastal assets in the City will largely depend on how the railroad corridor adapts to the existing and future coastal hazards.

Landward of the railroad tracks are coastal bluffs with heights of up to 100 feet above mean sea level (AMSL). Existing private and public development occupies much of the coastal bluff top throughout the City. Vulnerability of bluff top assets to SLR hazards is highly dependent on the presence of the existing rail corridor which functions as a shoreline protective device in much of the City.

In 2018, the OCTA was awarded an SB 1 grant from Caltrans to identify strategies to evaluate the effects of climate change and sea level rise on the OCTA-owned rail right-of-way in Orange County and develop strategies to promote resilience of the transportation services and assets. OCTA has indicated it will develop a Plan called the "*Orange County Rail Infrastructure Defense Against Climate Change Plan*" that will identify vulnerable locations, assess short- and long-term mitigation measures, and conduct cost estimates. The goal of the Plan is to build a resilient transportation system that is utilized by disadvantaged communities and military operations, as well as contributes to a thriving economy. City staff will be coordinating with OCTA staff during the development of this plan.

[1] NAVD88 is a vertical datum that is roughly 2.54 feet below mean sea level based on tidal datums at the La Jolla station (9410230) for the 1983-2001 tidal epoch.

Figure 4: Existing LOSSAN Railroad Corridor, North Reach, San Clemente

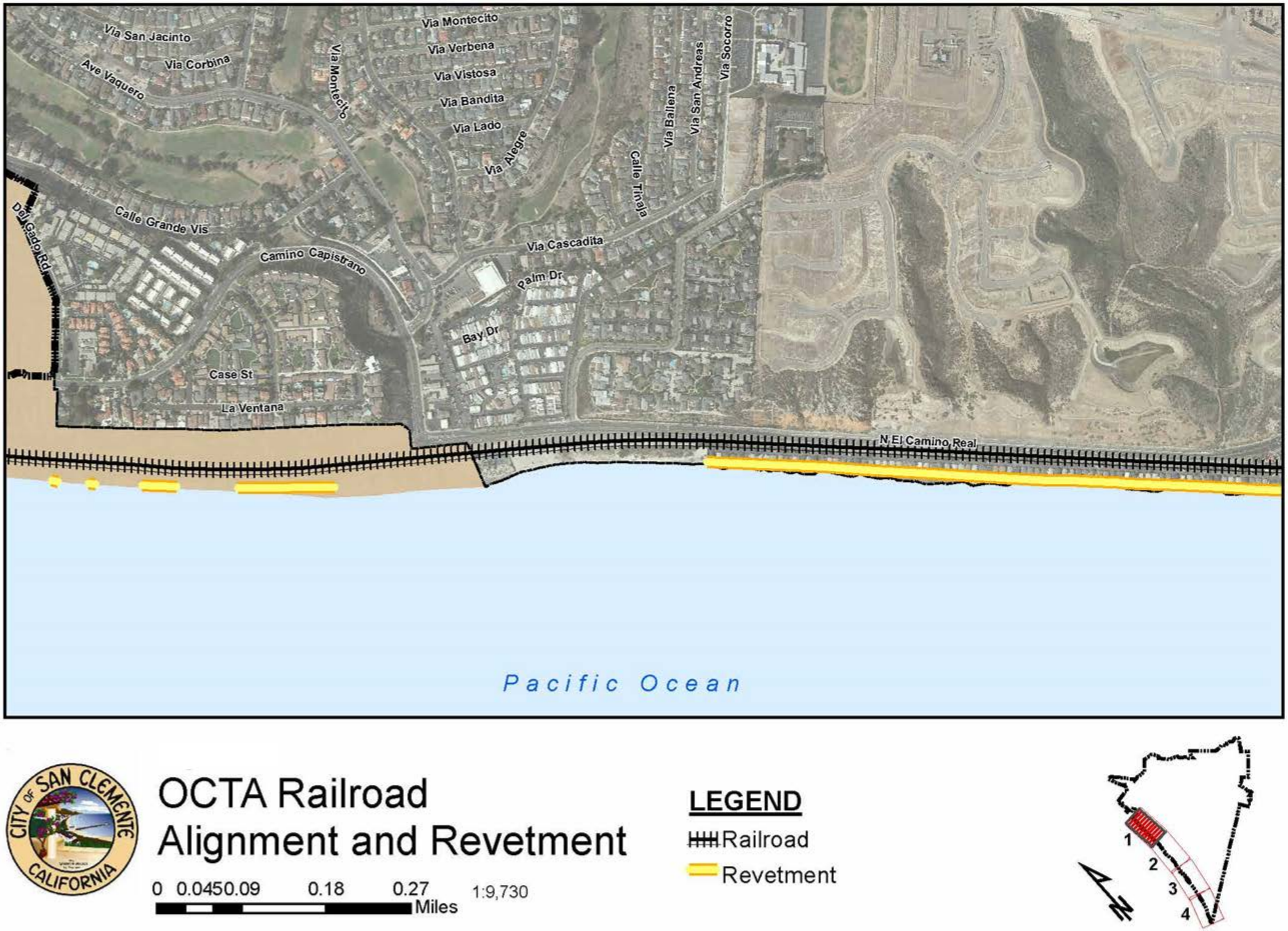


Figure 5: OCTA Railroad Alignment and Revetment (1 of 4)

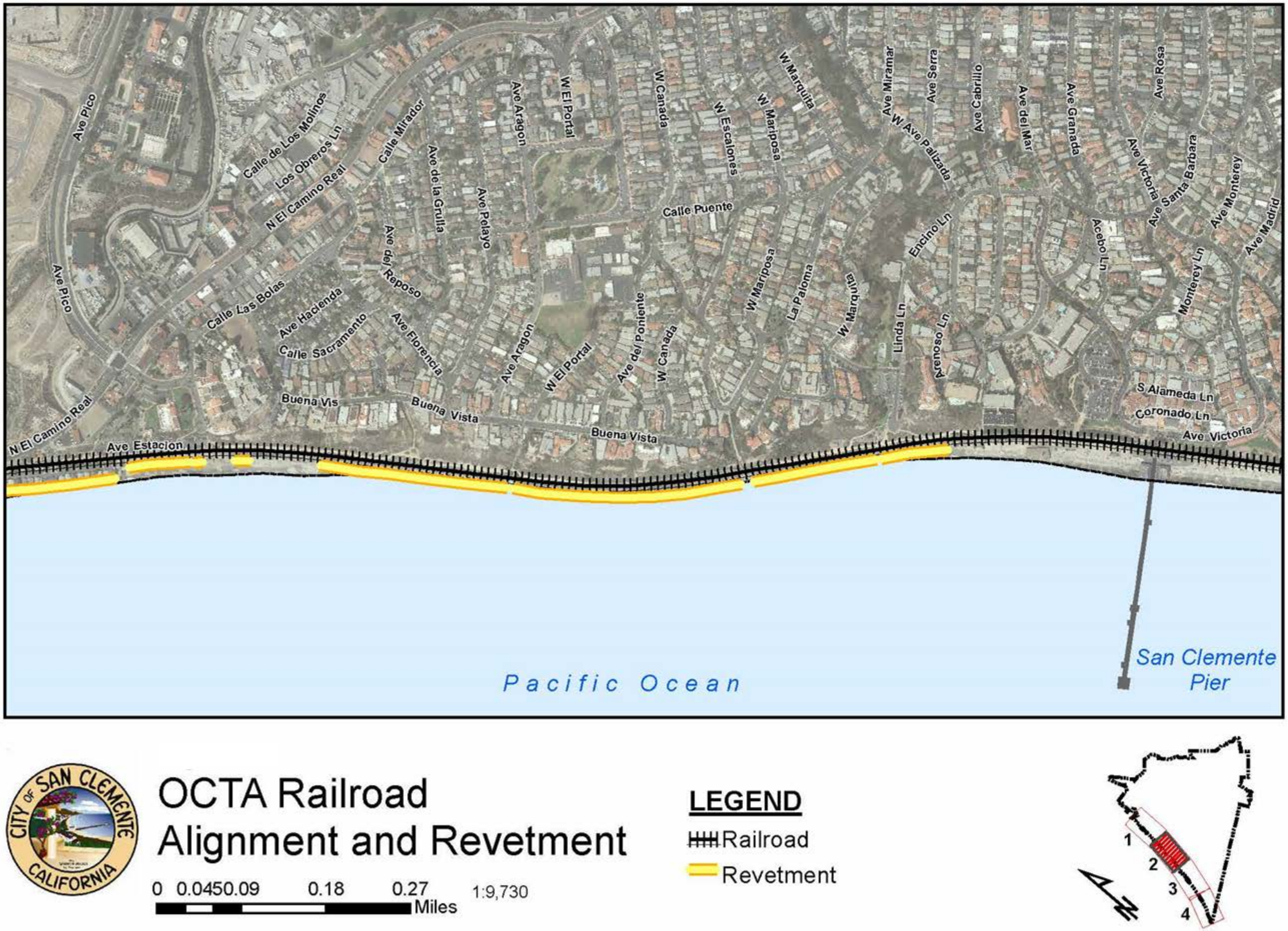


Figure 6: OCTA Railroad Alignment and Revetment (2 of 4)

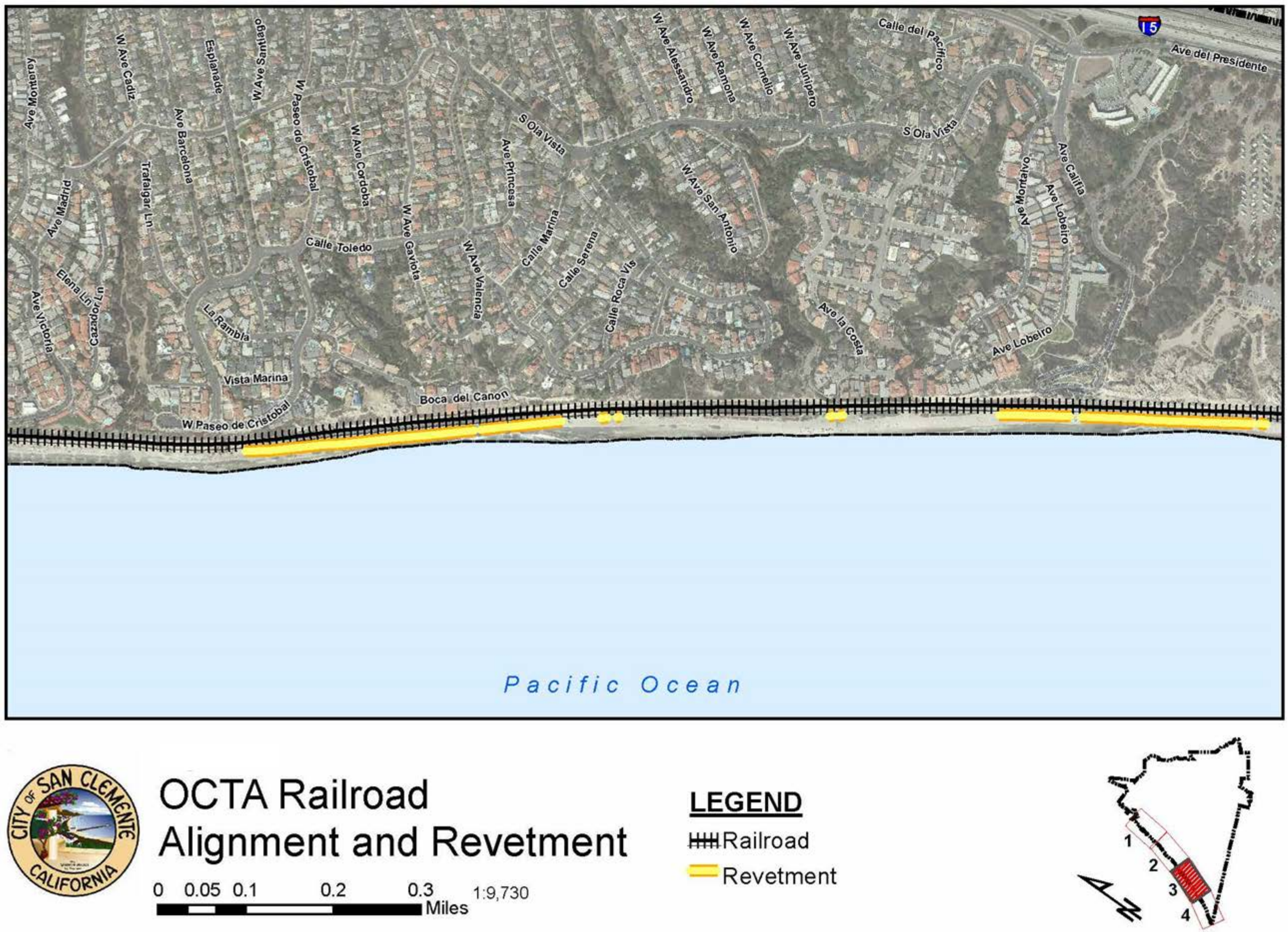


Figure 7: OCTA Railroad Alignment and Revetment (3 of 4)

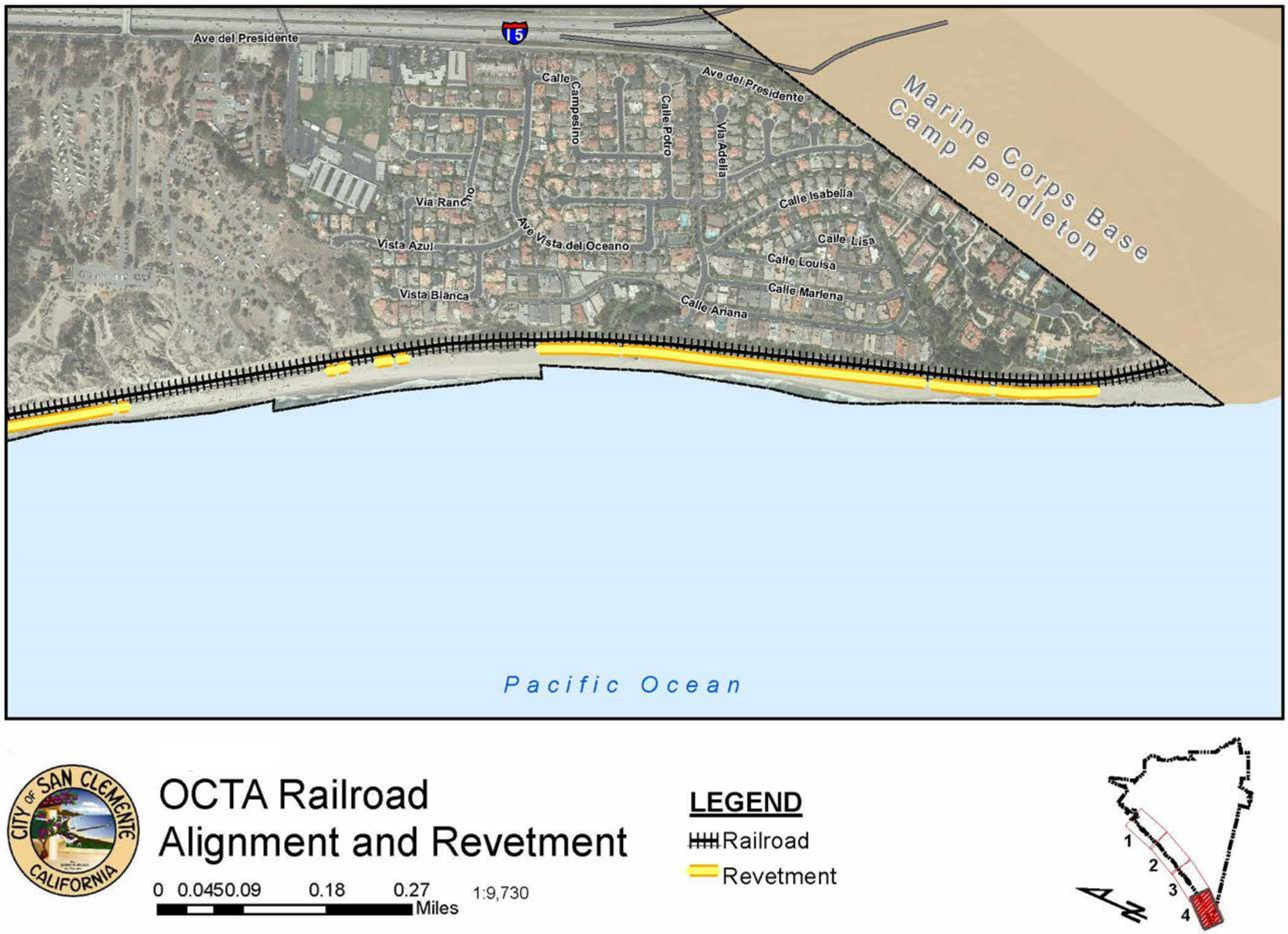


Figure 8: OCTA Railroad Alignment and Revetment (4 of 4)

2. Coastal Processes

Coastal processes refer to the waves, water levels, and sediment transport (including both long-shore and cross-shore) which shape the coastline of San Clemente. These dynamic processes are largely driven by natural forces but have also been significantly modified by anthropogenic activities (i.e. development, coastal structures and beach nourishment). This section describes historic coastal processes and how they have affected the shoreline along San Clemente. The influence of SLR on coastal processes is discussed in Section 4 of this Study.

2.1 Littoral Processes and Sediment Supply

A littoral cell is a coastal compartment or physiographic unit that contains sediment sources, transport paths, and sediment sinks (Patsch and Griggs, 2007). The City is within the Oceanside Littoral Cell, which extends from Dana Point on the north to La Jolla in the south. Longshore sediment transport in the City is predominantly from the north. The primary sources of littoral sediment for San Clemente's beaches are San Juan Creek to the north with smaller contributions from upland erosion of coastal dunes and bluffs. San Mateo Creek to the south is also a significant source of sediment to the littoral cell. However, since the net direction of sediment transport is toward the south, sediment from San Mateo Creek is not a major source for San Clemente beaches. Sediment sinks include aeolian (wind-blown) losses to dunes and cross-shore transport to offshore beyond the depth of closure. Some sinks, such as beach sand dunes, can later become sand sources as dunes erode during extreme wave events or as sea levels rise.

Fluvial (riverine) discharge from San Juan Creek is the largest natural source of sediment for the San Clemente coast. The sediment contribution to the local beaches from San Juan Creek has been estimated between 34,000 and 56,000 cy, on average, per year (Coastal Environments, 2014). The USACE (2012) estimated an average annual sediment delivery of 26,700 cy/yr from San Juan Creek and noted that most of this is likely lost offshore or trapped updrift of San Clemente. Figure 9 shows the delta formed at the San Juan Creek mouth in April 2005, several months after the major flood event that occurred on January 10-11, 2005.

Figure 9: San Juan Creek Delta, April 2005 (Google Earth)

The fluvial discharge rates listed above are averaged over a long period of time and do not necessarily reflect the episodic nature of these events. There have not been any notable discharges recorded from San Juan Creek since 2005. In addition to a recent lack of watershed storm events that deliver sediment to the coastline, other factors have contributed to a reduced long-term sediment yield from the watershed. Development within the watershed, construction of dams, water supply reservoirs and debris basins, continued sand and gravel mining all reduce the delivery of sediment to the coast. The Coast of California Storm and Tidal Wave Study (CCSTWS-SD) for the San Diego Region (USACE, 1991) estimated a 20-30% reduction of the natural (pre-dam) sediment yield from within the San Juan Creek watershed. That estimate was based on reports prepared in the late 1980s. In the three decades since those studies, watershed development has continued, and the net amount of sediment delivered to the coast has probably continued to decrease.

A study by Coastal Environments (2014) provided an assessment of littoral sediment transport patterns and a sediment budget for the coast between Dana Point and San Mateo Point (Dana Point Sub-cell). Data was aggregated from sediment studies spanning the 1980s to the 2000s, and it was estimated that the sediment budget for the Dana Point Sub-cell is in a 56,000 cy per year deficit (erosion) in dry years, and in a 3,000 cy per year surplus (accretion) in wet years. This discrepancy helps explain why the prolonged drought over recent years has resulted in shoreline erosion issues from Dana Point through San Clemente.

Beach nourishment has not provided a significant source of sediment to the littoral cell since the 1960s when over 1.6 million cubic yards of sediment was placed at the San Juan Creek mouth from upland and sea cliff sources, construction activities along San Juan Creek, and Dana Point Harbor construction (M&N, 2017). Other sediment management programs for Dana Point include 118,000 cy/yr over the 1960-1978 timeframe (USACE, 1991), as well as San Clemente's Opportunistic Beach Fill Program with project #1 adding 5,000 cy in 2005 and project #2 adding 12,000 cy of sand in December 2016.

The CCC approved up to 250,000 cy of nourishment for the City's beach nourishment program in 2014. Potential future sediment management programs include the USACE Coastal Storm Damage Reduction Project which would place approximately 250,000 cy from Linda Lane to T-Street Beaches (USACE, 2012) with the initial project with regular re-nourishment cycles occurring at various intervals over a 50-year project timeline. The USACE project EIR/EIS has been completed with all regulatory permits having been secured and the project has been authorized by the U.S. Congress under the federal Water Resources Development Art of (WRDA) of 2016. The project is currently in the Pre-Construction, Engineering and Design (PED) Phase and could begin as early as 2020 and would extend through a federally authorized 50-year period through 2070.

2.2 Shoreline Change

The narrow, bluff-backed beaches of San Clemente are sensitive to changes in sediment supply. The beaches in San Clemente primarily consist of a thin sand lens over a hard bottom (USACE, 2012). A sediment deficit, meaning more sediment leaves the sub-cell than is supplied, results in a trend of shoreline erosion. Long term shoreline changes are often related to sediment supply (described in Section 2.1), coastal storm conditions, and sea level rise. Long-term trends of erosion may be difficult to discern over short time scales (months to years) but over longer time scales (decades) shoreline change trends can have a significant impact on beaches.

A recent estimate of long-term shoreline change rates was provided in the San Clemente Shoreline Feasibility Study (USACE, 2012), based on an aggregate of data collected in support of the CCSTWS-SD (USACE, 1991) and the City's ongoing beach monitoring program. The results indicate a long-term trend of erosion at beach profiles near the Pier and State Beach. The mean shoreline change rate is -0.7 ft/yr. The highest rate of erosion (-2.0 ft/yr) was measured at T-Street. The only profile showing a positive shoreline change (accretion) in that timeframe was at Shorecliffs, north of Capistrano Shores and located in the Northern Reach. The shoreline change at this profile was similar in magnitude but opposite in direction as the other profiles. However, anecdotal reports indicate the shoreline change trend has reversed since then and resulted in significant erosion near the Shorecliffs location.

The San Clemente shoreline is also sensitive to water level changes and wave energy, which result in seasonal shoreline change patterns and storm induced erosion. Seasonal shoreline change is driven by differences in wave height and directional changes between summer and winter months. Smaller waves during the summer months allow the beach to advance seaward, resulting in a relatively wide beach that is popular with locals and visitors due to the recreational opportunities that are available. Larger waves during the winter months cut back (erode) the beach, resulting in a narrower beach width. A schematic of these seasonal changes is illustrated in Figure 10. The seasonal shoreline change was quantified in the CCSTWS-SD (USACE, 1991) with data collected prior to 1989 and measured a maximum seasonal shoreline change of about 100 ft at Linda Lane, with fluctuations on the order of ~50 ft measured at T-Street and San Clemente State Beach Park profiles.

Seasonal beach loss during winter months depletes the size and function of the storm buffer that is naturally provided by a wide sandy beach. Most of the historic coastal damage experienced in San Clemente has been a result of storm-induced erosion during the winter months. Storm related erosion can result in significant beach loss over the course of a few days. The most extreme events occur when large wave events coincide with high water levels such as the El Niño storm events during the 1982-1983 season, 1988 and most recently in 2016-2017.

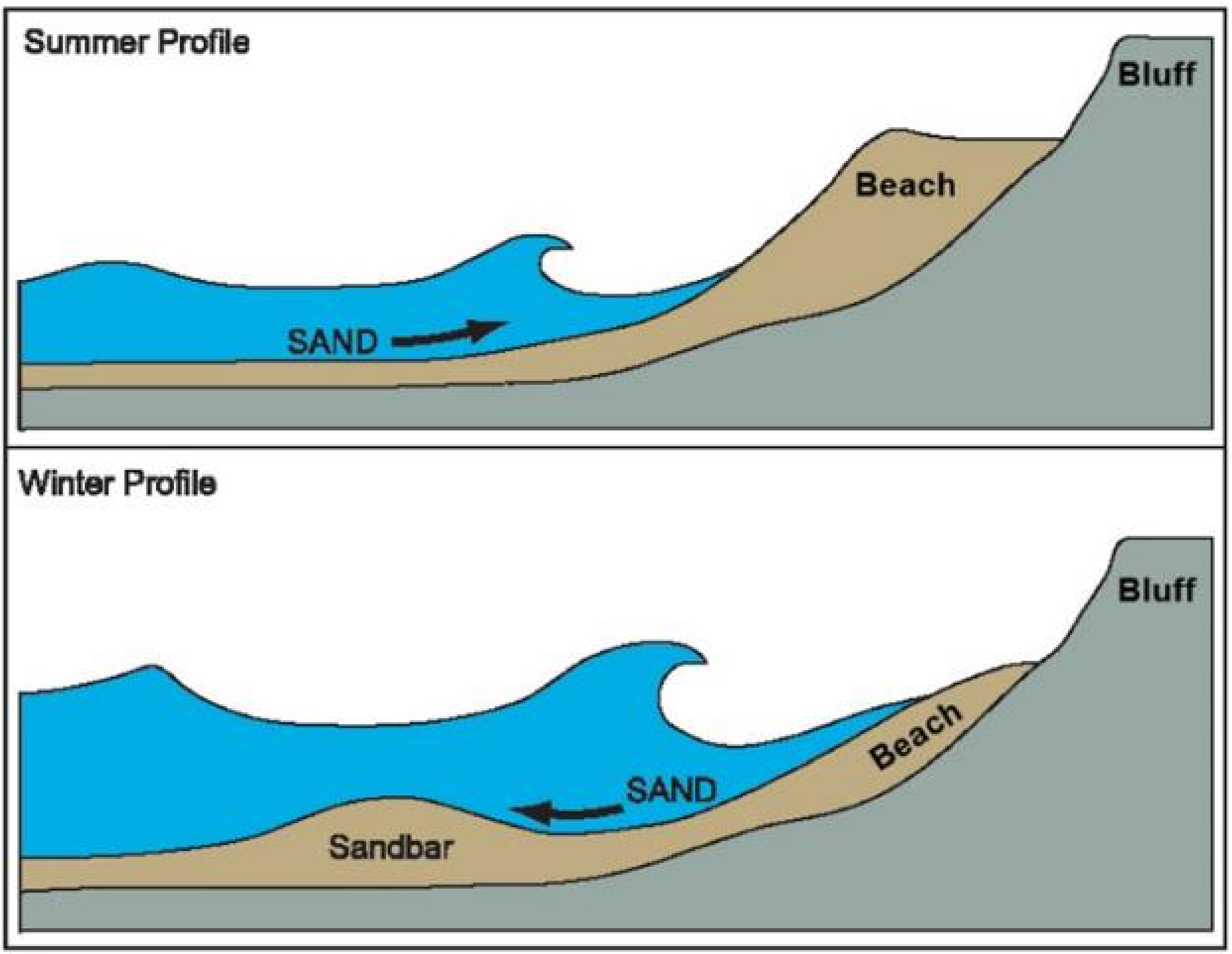


Figure 10: Schematic of Typical Seasonal Shoreline Change (Patsch and Griggs, 2007)

2.3 Water Levels

The tides in San Clemente are mixed semidiurnal, with two high tides and two low tides of differing magnitude occurring each day. Astronomical tides make up the most significant amount of 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 ft based on the tidal station at La Jolla (NOAA station 9410230). The gage is located on the Scripps Pier and has been collecting data since 1924. During spring tides, which occur twice per lunar month, the tide range increases to about 7 ft due to the additive gravitational forces of the sun and moon. During neap tides, which also occur twice per lunar month, the forces of the sun and moon partially cancel out, resulting in a smaller tide range of about 4 ft. The largest tides of the year are sometimes referred to as “King” tides and result in high tides of 7 ft or more above MLLW and tidal ranges more than 8 ft.

In addition to astronomical tides, factors such as sea level anomalies (El Niño events) and storm surge also contribute to changes in relative water levels along the San Clemente shoreline. These factors can increase the predicted tides over the course of several days lasting to several months. An example of this occurred on November 25 and 26, 2015 when a king tide of about 6.7 feet above MLLW was predicted but a water level of 7.8 feet was measured at NOAA station 9410230 in La Jolla. The tide series from this event is shown in Figure 11. The predicted astronomical tide was elevated by more than 1 foot due to a sea level anomaly related to the strong El Niño and high ocean temperatures during the 2015-2016 winter season (Doherty 2015). The water levels of late November 2015 exceeded the 100-year water level of 7.6 feet on two consecutive days at this tide station.

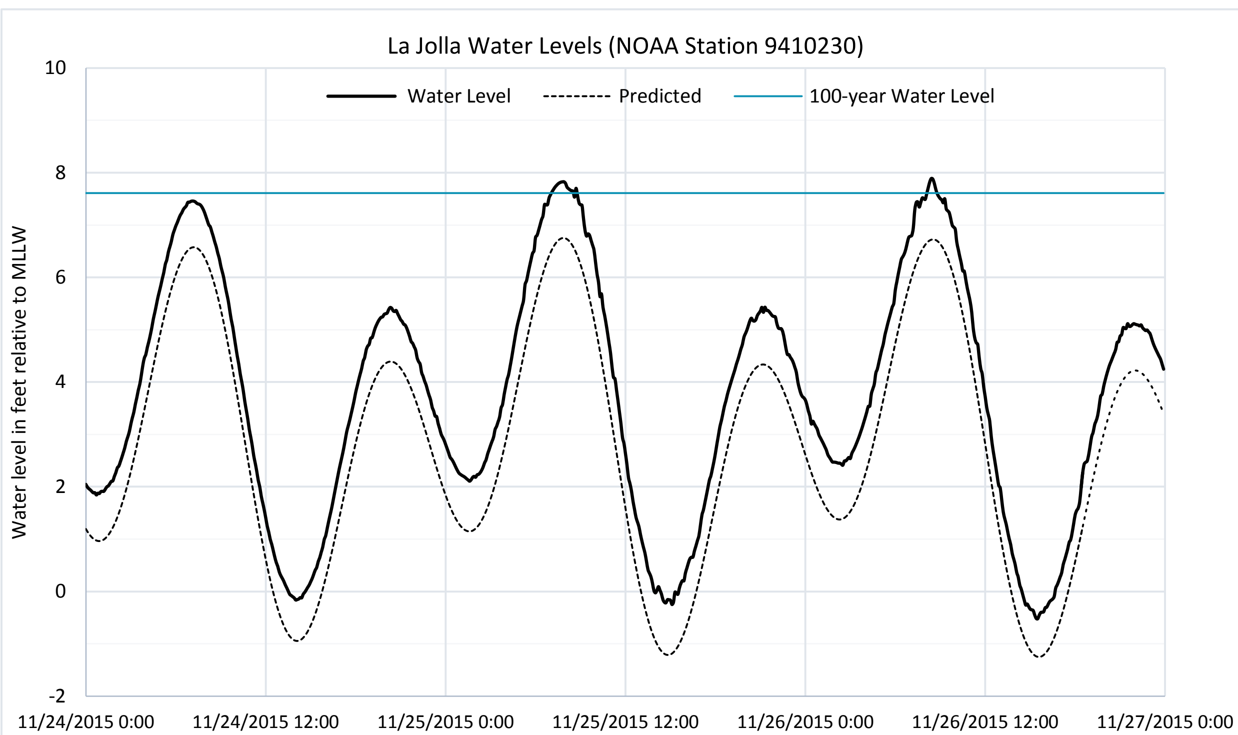


Figure 11: November 2015 Water Levels (NOAA Station 9410230)

2.4 Wave Climate

Waves act to carry sand in both the cross-shore and longshore directions and can also cause short-duration flooding events by causing dynamic increases in water levels. Thus, the wave climate (or long-term exposure of a coastline to incoming waves) and extreme wave events are important in understanding future SLR vulnerabilities.

The general wave exposure of San Clemente is characterized by south swells in summer, which are typically smaller wave heights with long wave periods, and west-northwest swells in winter months that have much larger wave heights (i.e. 10-yr, 50-yr wave heights) and typically shorter wave periods due to the storms closer proximity to the coast. While extreme wave events have caused damage to City facilities in the past, the year-round wave exposure is also considered an asset to the surfing community of San Clemente. Exposure to a wide range of swells make for consistent waves at a variety of breaks along the coast and contributes the popularity of surfing in San Clemente, as shown in Figure 12.

Figure 12: Surfing at San Clemente Municipal Pier

The most localized and accurate wave data for San Clemente comes as part of the Coastal Data Information Program (CDIP). The CDIP's shallow-water gage (ID 052) was located approximately 1,000 feet offshore of the pier in about 30 ft of water. The gage collected measurements from 1983 to 1998 before it was de-commissioned, with a gap from July 1988 to July 1991 (USACE, 2012). The range of the most commonly occurring significant wave height was 2.7 - 3.3 ft with a maximum wave height of 12 ft measured January 18, 1988 (USACE, 2012). Table 2 provides a summary of the maximum significant wave height recorded in each of the years that the gauge was operational.

The significant wave height is defined as the average of the highest one-third of waves in a wave spectrum. The theoretical maximum wave height in a given spectrum can be two times the significant wave height. For example, during the January 30, 1998 event the largest significant wave height measured offshore of the pier was about 10 ft. During this same storm, the actual maximum wave heights may have reached 20 ft.

Moffatt & Nichol (1983) prepared a detailed summary of the oceanographic conditions during the 1983 El Niño winter storms and developed recommended design parameters for repairs to the San Clemente Municipal Pier after the March 1983 El Nino event. The estimated extreme wave heights at the western end of the pier ranged from 20 ft to 25 ft. The study also noted several nearshore reefs near the pier, which can focus wave energy due to shoaling and wave refraction. The shoal directly seaward of the pier tends to focus wave energy toward the pier area, which can amplify wave heights at this location. Extreme waves during the 1988 El Niño event are shown in the photograph in Figure 13.

Table 2: Annual Maximum Significant Wave Height near San Clemente Municipal Pier, 1983-1998 (USACE, 2012)

Date	Significant Wave Height (ft)
12/10/1983	10.2
04/01/1984	6.1
11/29/1985	7.2
02/16/1986	11.7
03/16/1987	7.4
01/18/1988	11.9
11/15/1991	6.8
01/30/1992	7.6
02/18/1993	8.7
02/07/1994	6.6
01/05/1995	10.6
10/26/1996	7.4
12/06/1997	7.6
01/30/1998	9.8

Figure 13: Storm Waves at San Clemente Municipal Pier during 1988 El Niño storm.
Image: Fred Swegles, OC Register

2.5 History of Coastal Storm Damage

Coastal assets in San Clemente are particularly susceptible to damage from extreme storm events that typically occur during strong El Niño Southern Oscillation events. Particularly notable historic storm events that resulted in damage to City facilities are summarized below. Sea level rise is expected to intensify the effects of these storm events by elevating water levels and wave heights relative to fixed infrastructure such as the pier, Marine Safety Building and railroad.

- Winter Storms of 1982-1983 El Niño: A sequence of eight major storms struck the California coast between November 1982 and mid-March 1983. The waves associated with these storms were exceptional because of their height, long periods, and more westerly approach. Coastal damage was aggravated by the synchronization of the storms with unusually extreme water levels, driven by tides, storm surges, and El Niño effects. The March 1-2, 1983 event destroyed the outer 440 feet of the San Clemente Municipal Pier (M&N, 1983) due to large and long period swell from the west combined with large locally generated waves from the south. The City spent about $2.1 million dollars on pier repairs after this event.
- Winter storm on January 17-18, 1988 El Niño: High tides and storm waves during this period caused additional damage to the pier. The City spent about $2.3 million dollars on pier repairs after this event.
- El Niño of 1997-1998: Strong waves during the winter season of 1997-1998 damaged the Marine Safety Building. Damage during this event and others have necessitated construction of a seawall and multiple repairs to prevent undermining of the Marine Safety Building (USACE, 2012).
- El Niño of 2015-2016: With a sea level anomaly measuring approximately 1 ft above predicted tides and winter wave energy meeting or exceeding historic measurements, the 2015-2016 event was one of the strongest on record. Shorelines retreated beyond previously measured extremes in many locations as wave energy eroded beaches, starved of riverine sediment from a multi-year drought and an unusually dry El Niño, limiting beach recovery (Barnard et al., 2017).
- Recent storms such as in the winter of 2016-2017, have exacerbated the trend of shoreline erosion with significant impacts on beach use. As shown in Figure 14, the swell peak coincided with an average tidal cycle, which limited the damage at North Beach and other facilities. The restroom building at North Beach was undermined by coastal erosion during this event as shown in Figure 15.

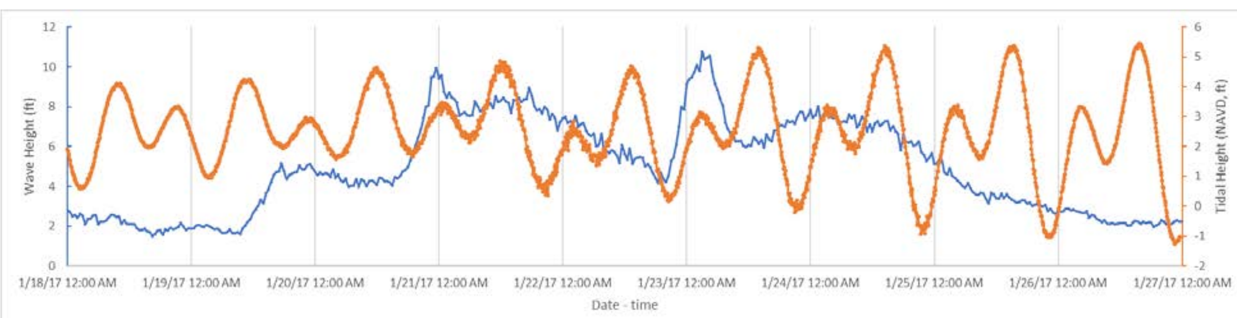


Figure 14: Significant Wave Height and Water Levels, January 2017 Storm (CDIP Buoy 46262 – Oceanside)

Figure 15: North Beach Restroom, January 2017 (OC Register)

Coastal storm-related damage also affected the LOSSAN railroad, resulting in two service disruptions of approximately 24 hours. One incident occurred in the 1960s north of the Municipal Pier, and another in the 1970s south of the Pier. Both interruptions were a result of wave overtopping of the railroad ballast that eroded the embankment (USACE, 2012).

The highest waves on record (≈ 27 ft) were generated by a tropical storm off the west coast of Mexico in September 1939. Newspaper reports (The Register, 1983) indicate that the 1939 storm was the only other time the San Clemente Municipal Pier had to be rebuilt other than after the impacts of the 1983 El Niño season (M&N, 1983).

3. Sea Level Rise (SLR) Projections

Sea level rise science involves both global and local physical processes. Models are created based on science's current best understanding of these processes from global to local scales and, therefore, are dynamic and periodically updated to reflect these changes. On a global level, the most recent predictions come from the Intergovernmental Panel on Climate Change's 5th assessment report released in 2013. The 5th assessment projections for sea level rise were 50% higher than the previous assessment (released in 2007) due to the addition of melting ice sheet dynamics on sea level rise. At the state level, the California Coastal Commission presently recommends the *State of California Sea Level Rise Guidance* (OPC 2018) that was released in March 2018. These projections update the 2013 SLR projections and future updates are expected to occur at approximately 5 year intervals.

3.1 Projections and Probability

The OPC (2018) Guidance projects SLR 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 La Jolla tide gauge are referenced in this section as the nearest and most applicable/relevant for the City of San Clemente. CCC SLR Policy Guidance recommends the cities consider using projections associated with a high emissions future given that worldwide emissions are currently following the high emissions trajectory.

Climate science is a constantly changing field with high degrees of uncertainty. In the case of California, the OPC has high confidence in estimates for sea level rise up to around Year 2050, after which, greenhouse gas emissions scenarios cause predictions to significantly diverge. For the 2050 time horizon the "likely range" of SLR is between 0.7 to 1.2 feet. Kopp et al. 2014 estimated there is a 66% probability that SLR will fall within this "likely range". The likely range of SLR at the 2100 time horizon is 1.8 – 3.6 feet for a high emissions scenario.

The 2018 California State Guidance Document lays out a risk decision framework that explains when to consider use of a low, medium or high-risk aversion (e.g., levels of risk tolerance that are willing to be accepted given the uncertainties in the models and the probabilities of the SLR scenarios occurring within the projected horizon years / timeframes) in the planning process. With this framework, the probabilistic projections inform the decision-making process rather than trying to estimate the exact rate or occurrence of SLR based on an individual scenario or projection.

The upper end of the "likely range" is recommended for low risk aversion (i.e., higher risk tolerance) situations where impacts from SLR greater than this amount would be insignificant, or easily mitigated. The State recommends this high-risk tolerance (low aversion) to be used when considering resources where the consequences of SLR would be limited in scale and scope with minimum disruption and where there would be a low impact on communities, infrastructure, or natural systems. This "low risk aversion" curve is shown in orange in Figure 16. At any given time horizon there is a 17% chance that SLR will exceed this curve.

For medium-high risk aversion situations more conservative (i.e., has a lower probability of occurrence) projections for SLR are recommended by the OPC Guidance. It should be noted that these projections currently have a 1-in-200 chance (0.5% probability) of occurring at a given time horizon and may be appropriate for use on projects where damage from coastal hazards would carry a higher consequence and/or a lower ability to adapt such as residential and commercial structures with a longer design life (75-100 years). A sea level rise of 2 feet is projected at the 2050 time horizon, 3.6 feet at 2070 and 7.1 feet at 2100 for “medium-high” risk aversion applications. The “medium-high risk aversion” curve is shown in red in Figure 16.

The OPC guidance also includes a specific singular scenario (called H++), based on projections by Sweet et al 2017 which incorporates findings of Pollard and DeConto (2016) that predict Antarctic ice sheet instability could make extreme sea-level outcomes more likely than indicated by Kopp et al. 2014 (OPC, 2017). Because the H++ scenario is not a result of probabilistic modeling the likelihood of this scenario cannot be determined at this time. Due to the extreme and uncertain nature of the H++ scenario, the State notes that it is most appropriate to consider using this extreme scenario when planning for development that poses a high risk to public health and safety, natural resources and critical infrastructure (OPC 2018). The H++ extreme risk aversion curve is shown in purple in Figure 16. The likelihood of this scenario occurring is unknown and therefore should be acknowledged but is not recommended for use in LCP planning documents related to decision making in the near term.

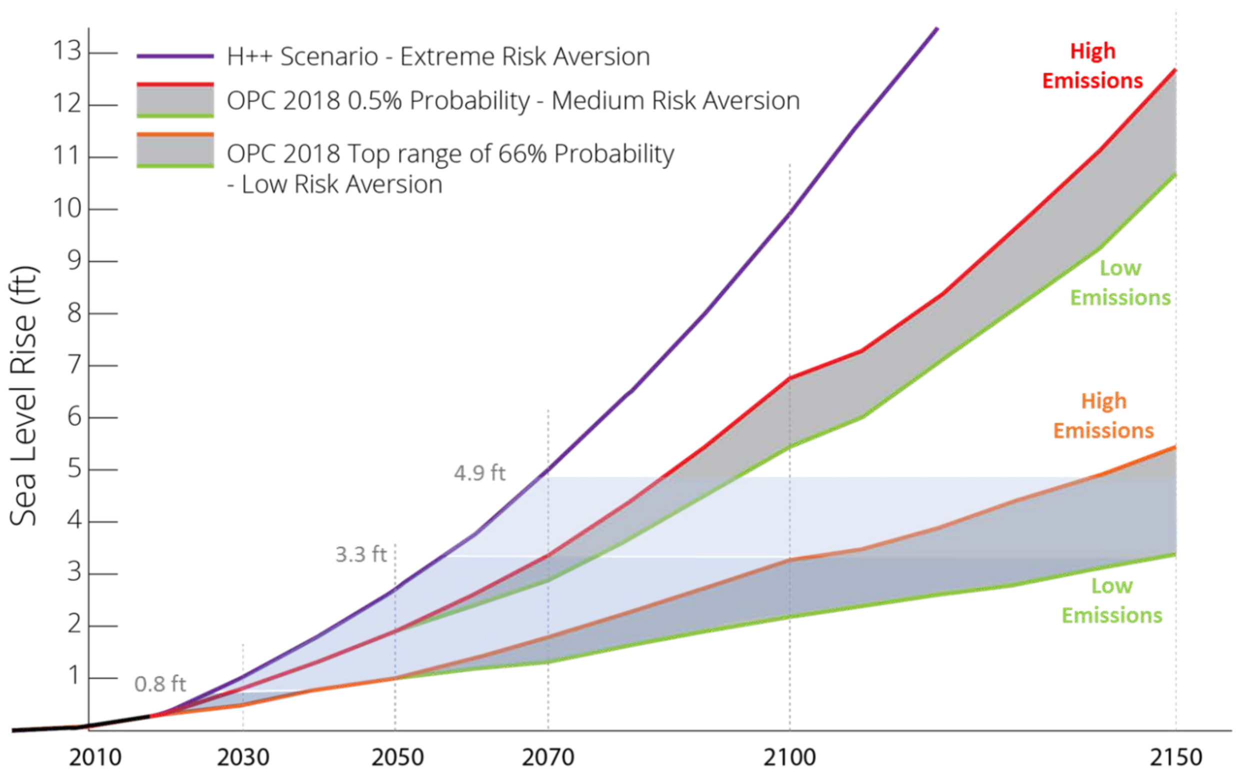
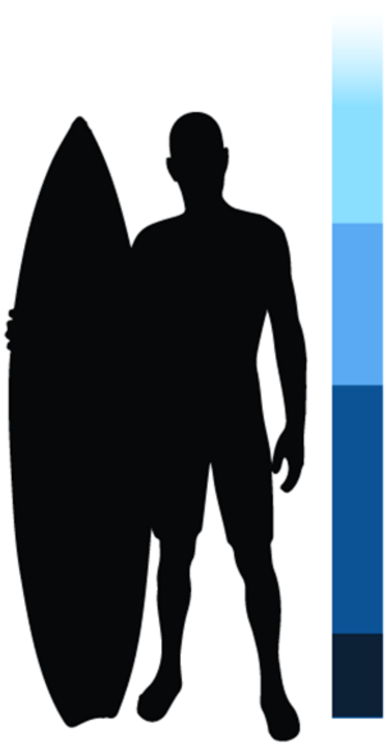


Figure 16: Approximate Sea Level Rise Projections for Three Risk Aversion Levels (OPC, 2018)

Planning for a varying degree of SLR is challenging and will require periodic updates based on the most recent predictions and as a result of tide gauge monitoring and other local monitoring efforts. This data may help reduce uncertainty and will be used as a reality check against SLR predictions and ultimately to inform SLR projections and the City's coastal resiliency and adaptation planning efforts.

3.2 General Overview of SLR Scenarios Evaluated in this Study:

Based on the guidance from the CCC Sea Level Rise Policy Guide to evaluate a "range of possible scenarios," and coordination with CCC staff, three sea level rise scenarios (shown in Figure 17) were selected for use in this Study. Sea level rise scenarios were selected based on an initial screening of coastal resource vulnerabilities and provide a basis for understanding how hazards and vulnerabilities change with each increment of SLR evaluated. The range of scenarios selected cover the likely range of SLR projections through 2130 and the worst-case SLR projections through 2070. In accordance with the CCC LCP Planning Grant, the 4.9-foot SLR scenario included an evaluation of hazards in the event the railroad and revetment are relocated inland or otherwise removed from the current location at some point in the future.



Sea level Rise above '91-'09 baseline	When might it occur?*
4.9 feet (150 cm)	2070 to 2130
3.3 feet (100 cm)	2060 to 2100
0.8 feet (25 cm)	2030 to 2040

* ranges are approximate and estimated from OPC State of CA SLR Guidance (2018)

Figure 17: Selected Sea Level Rise Scenarios and Range of Occurrence

The potential timing of each scenario is based on the high emissions projections at La Jolla from Table 31 of the OPC guidance. The approximate range of when each scenario may occur reflects the difference between low and extreme risk aversion projections. For example, 0.8 feet (25 cm) is similar to the low risk aversion projection for 2040 which means it is within the likely range of projections for that time horizon.

Under a worst case SLR scenario (extreme risk aversion projection) 0.8 feet of SLR could occur before 2030. The next SLR scenario of 3.3 feet is representative of the low risk aversion projection in 2100 and the medium-high risk aversion projection in 2070. The extreme risk aversion projection indicates 3.3 feet of SLR could occur before 2060.

The SLR scenario of 4.9 feet is representative of the low risk aversion projection in 2130 which means it is unlikely to occur before that timeframe. This scenario is also representative of the worst-case, extreme risk aversion, projection for 2070. The increasing range of when each scenario may occur is indicative of the greater uncertainty associated with SLR projections beyond 2050.

The scenarios selected represent key thresholds at which significant impacts to coastal resources would theoretically be expected to occur regardless of the year in which they may occur. The impacts from these scenarios, discussed in Sections 4 and 5, are based on the assumption that there would not be an action or actions taken by the City or others to implement an SLR adaptation strategy to mitigate impacts from SLR (e.g., such as the USACE beach nourishment project). Therefore, these impacts should be viewed as what may occur if no preventative or pre-emptive action is implemented by the City or by others in the future. The following is a brief summary of the thresholds at each SLR scenario:

- **0.8 ft (25 cm) SLR:** Existing sandy beaches erode and lose about half their width, some areas (North Beach and Mariposa Point) erode completely to the railroad impacting coastal access, recreation and the environmental resources seaward of the railroad. Structures on the beach, including the Pier and Marine Safety Building, are vulnerable to more frequent storm related flooding, damage, erosion, scour, and undermining.
- **3.3 ft (100 cm) SLR:** Most sandy beaches are eroded up to the railroad, small beaches may exist seasonally and at low tide. Shoreline erosion projections (Section 4) indicate this may be close to a threshold point for the railroad corridor as the railroad would be subject to repeated wave attack and flooding during high tides and storm events.
- **4.9 ft (150 cm) SLR:** This scenario assumed the railroad and revetment has been relocated and removed from service in its current location. Under this assumption shoreline retreat could reach the coastal bluffs. Parcels atop the bluff would be vulnerable to bluff failures resulting from increased wave action at the toe in the absence of the protective railroad revetment, or some other form of adaptation.

4. Evaluation of Sea Level Rise and Related Hazards

The effects of SLR on coastal processes such as shoreline erosion, storm related flooding and bluff erosion were evaluated using results of the Coastal Storm Modeling System (CoSMoS) version 3.0, Phase 2. CoSMoS is a multi-agency effort led by the United States Geological Survey (USGS) to map detailed predictions of coastal flooding and erosion based on existing and future climate scenarios for Southern California. The modeling system incorporates state-of-the-art physical process models to enable prediction of currents, wave height, wave runup, and total water levels (Barnard, P.L. et al., 2009). The results provide predictions of shoreline erosion (storm and non-storm), coastal flooding during extreme events and bluff erosion. The hazards depicted in this Study are presented solely based on the assumptions and limitations accompanying the CoSMoS 3.0 data available at the time of this Study. No additional numerical modeling or independent verification of the CoSMoS data was performed.

4.1 CoSMoS 3.0 Sea Level Rise Scenarios

A total of 10 SLR scenarios are available, these include 0.8 ft (0.25 m) increments from 0 to 6.6 ft (0 to 2 m) and an extreme sea level rise scenario of 16.4 ft (5 m). Table 3 summarizes the SLR scenarios that are available from CoSMoS Version 3.0 Phase 2. Shoreline erosion projections are available for each SLR scenario and four management scenarios. Management scenarios defined in the model include with and without beach nourishment and coastal armoring (i.e. “Hold-the-Line” or “No Hold-the-Line” (also known as “Managed Retreat”)). Flood hazards are only available for the “Hold-the-Line, No Beach Nourishment” management scenario.

All coastal hazard data from CoSMoS 3.0 can be viewed from the Our Coast, Our Future (OCOF) web tool which provides a useful interface for mapping the different scenarios (http://data.pointblue.org/apps/ocof/cms/).

Table 3: Summary of CoSMoS Version 3.0 Phase 2 Scenarios

Planning Horizon, Year	Management Scenario Description	Sea Level Rise, ft (m)	Available Data
Current – 2100	Hold-the-Line, Beach Nourishment	0 – 6.6, 16.4 ft (0 – 2, 5 m)	Shoreline erosion
Current – 2100	Hold-the-Line, No Beach Nourishment	0 – 6.6, 16.4 ft (0 – 2, 5 m)	Flood hazards and shoreline erosion
Current – 2100	No Hold-the-Line, Beach Nourishment	0 – 6.6, 16.4 ft (0 – 2, 5 m)	Shoreline erosion
Current – 2100	No Hold-the-Line, No Beach Nourishment	0 – 6.6, 16.4 ft (0 – 2, 5 m)	Shoreline erosion

4.2 Coastal SLR-Related Flooding

Coastal flooding predictions simulate the effects of erosion, wave runup, and overtopping during storm events. Future storm event scenarios for typical conditions, 1-year (100% annual chance), 20-year (5% annual chance), and 100-year (1% annual chance) are available for each SLR scenario. Flooding extents are calculated and mapped at profiles spaced about 300 feet apart along the shoreline. The projected water levels used in the flood mapping consider future shoreline change, tides, sea level anomalies like an El Niño, storm surge, and SLR. Future wave conditions used in the model are based on forecasted conditions out to year 2100.

Flooding results are available only for the “Hold the Line, No Beach Nourishment” management scenario, which assumes future shoreline erosion will be halted at the existing development line and protected by coastal structures. The “Hold the Line” assumption restricts shoreline erosion landward of existing development in the model, which in San Clemente is typically at the seaward edge of the railroad, but flooding is allowed to occur beyond this point. It is not clear what specific assumptions were made in CoSMoS 3.0 in terms of the type and height of the coastal structure assumed to be in place, or the potential for scour to occur in front of such a structure.

Given the narrow beaches of San Clemente, the “Hold the Line” assumption limits the extent of coastal flooding predictions for nearly all SLR scenarios to the area seaward of the railroad. This is a key limitation that reduces the utility of flood hazard projections in this study. Since the flood modeling assumes the line of development is held in place in perpetuity, it is not representative of existing conditions nor how flood hazards would migrate landward with additional SLR.

The CoSMoS storm flooding projections generally indicate existing development and resources seaward of the railroad that are exposed to coastal storm flooding today will be exposed to greater amounts of flooding with each increment of sea level rise in the future. The 100-year storm flood hazards for each SLR scenario are shown in Figure 18 at North Beach. Landward of the railroad there is no significant coastal flooding predicted by CoSMoS for the future SLR scenarios, including the 4.9 foot SLR scenario. It may be prudent to verify this CoSMoS finding in a subsequent effort to the extent that this information is referred to by OCTA as part of its SB 1 Grant implementation project. The CoSMoS modeling effort did not take into account the adaptive capacity of the existing revetments and their ability to accommodate increased erosion, water levels and wave energy associated with each increment of SLR.

Since the storm flood projections provided by CoSMoS relied on a “Hold the Line” assumption they do not provide a worst-case scenario for potential hazards associated with each increment of SLR. Coastal erosion in both storm and non-storm conditions is of greater concern to coastal resources since these processes often result in greater impacts with pro-longed recovery after an extreme event. Therefore, the CoSMoS-COAST shoreline erosion projections were used to assess the exposure of coastal resources at each increment of SLR, including the potential scenario in which the railroad is relocated in the future.

Figure 18: CoSMoS 100-yr Storm Flooding, North Beach (OCOF)

4.3 SLR- Related Shoreline Erosion Projections

CoSMoS 3.0 results predict long-term erosion resulting from SLR and projected wave conditions. Beach erosion was modeled with the CoSMoS Coastal One-line Assimilated Simulation Tool (CoSMoS-COAST), which comprises a suite of models that consider historic erosion trends, long-shore and cross-shore sediment transport, and changes due to SLR. These models were calibrated with historic data to account for unresolved sediment transport processes and inputs, such as sediment loading from rivers and streams, regional sediment supply (beach nourishment and sand bypassing), and long-term erosion. Future shoreline positions were predicted for the four management scenarios as shown in Table 3.

The “Hold-the-Line” scenario assumes that the existing boundary between sandy beach and development is maintained with coastal structures. There is no “Hold-the-Line” model output that shows erosion inland to the maximum potential erosion extents as is shown in other model outputs where a managed retreat or planned retreat scenario is implemented.

The “Beach Nourishment” scenario assumes historical beach nourishment rates are carried forward into the future. “No Beach Nourishment” assumes the beach is left in its existing state. With no regular beach nourishment program in San Clemente, the model predicted difference between with and without beach nourishment is minimal. It’s important to note that the CoSMoS-COAST shoreline projections do not account for the planned USACE beach nourishment program described in the San Clemente Shoreline Feasibility Study (USACE, 2012), nor do they account for the recent opportunistic beach fill projects conducted by the City. If these adaptation strategies are implemented in the future, then it may indicate that the projected erosion due to each SLR scenario may be less than depicted.

The CoSMoS COAST shoreline projections are based on an initial shoreline position mapped from a 2009-2011 LIDAR data set. Therefore, the initial shoreline doesn’t reflect the recent erosion driven by a sediment supply deficit and El Niño storm events. In many locations the current shoreline is significantly landward of the CoSMoS “initial shoreline,” especially at North Beach. This would indicate that perhaps the projected erosion due to each sea level rise scenario may reach further inland than depicted.

The “No Hold-the-Line, No Beach Nourishment” management scenario was used to illustrate how the San Clemente shoreline will migrate landward under storm and non-storm conditions and different amounts of SLR. This management scenario depicts future shoreline conditions assuming existing or future development does not restrict the evolution of the shoreline and provides a method for evaluating the vulnerability of resources landward of the railroad corridor as required by the terms of the CCC grant agreement.

4.4 Sea Level Rise Exposure – North Reach

The exposure of resources along the north reach were evaluated using “No Hold-the-Line, No Beach Nourishment” shoreline erosion projections from CoSMoS-COAST. The shoreline erosion projections are mapped along with the coastal assets for the North Reach in Figure 19. The results indicate 0.8 ft (25 cm) of sea level rise would cause 20 to 40 ft of shoreline retreat at North Beach and an additional 10-20 ft of storm erosion potential. Similar amounts of erosion are predicted at Poche Beach and the Shorecliffs Beach Club, a private development.

An illustration of the exposure rating for physical assets along the north reach is provided in Figure 20. A low exposure (green) was assigned if the asset was located outside of the storm and non-storm shoreline projections. A moderate exposure (orange) was assigned if the asset falls within the winter storm erosion bands depicted in red on the plan view figures. A high exposure rating (red) was assigned if the asset is within the non-storm hazard zone depicted by the yellow line on the plan view figures. These exposure ratings are based on the CoSMoS data that does not reflect the recent erosion trend. In several of the figures it is evident that the shoreline depicted in the aerial image is landward of the shoreline position predicted for 0.8 ft (0.25m) of SLR.

Sandy beach areas and access points along the North Reach are most exposed to impacts from shoreline erosion resulting from 0.8 ft (25 cm) of sea level rise. The LOSSAN railroad will also experience increased wave action against the existing revetment. Nearly all assets have moderate to high exposure under a 3.3 ft (100 cm) sea level rise scenario. The CoSMoS shoreline projections indicate the active shoreline will be at or very close to the railroad corridor during non-storm conditions. The shoreline projections for a 4.9-foot sea level rise scenario indicate the shoreline would retreat landward of the railroad corridor to the bluffs (assuming the railroad is relocated or removed from service in the future). Under this scenario the bluffs would be subject to wave action exposing the bluff-top development to erosion hazards.

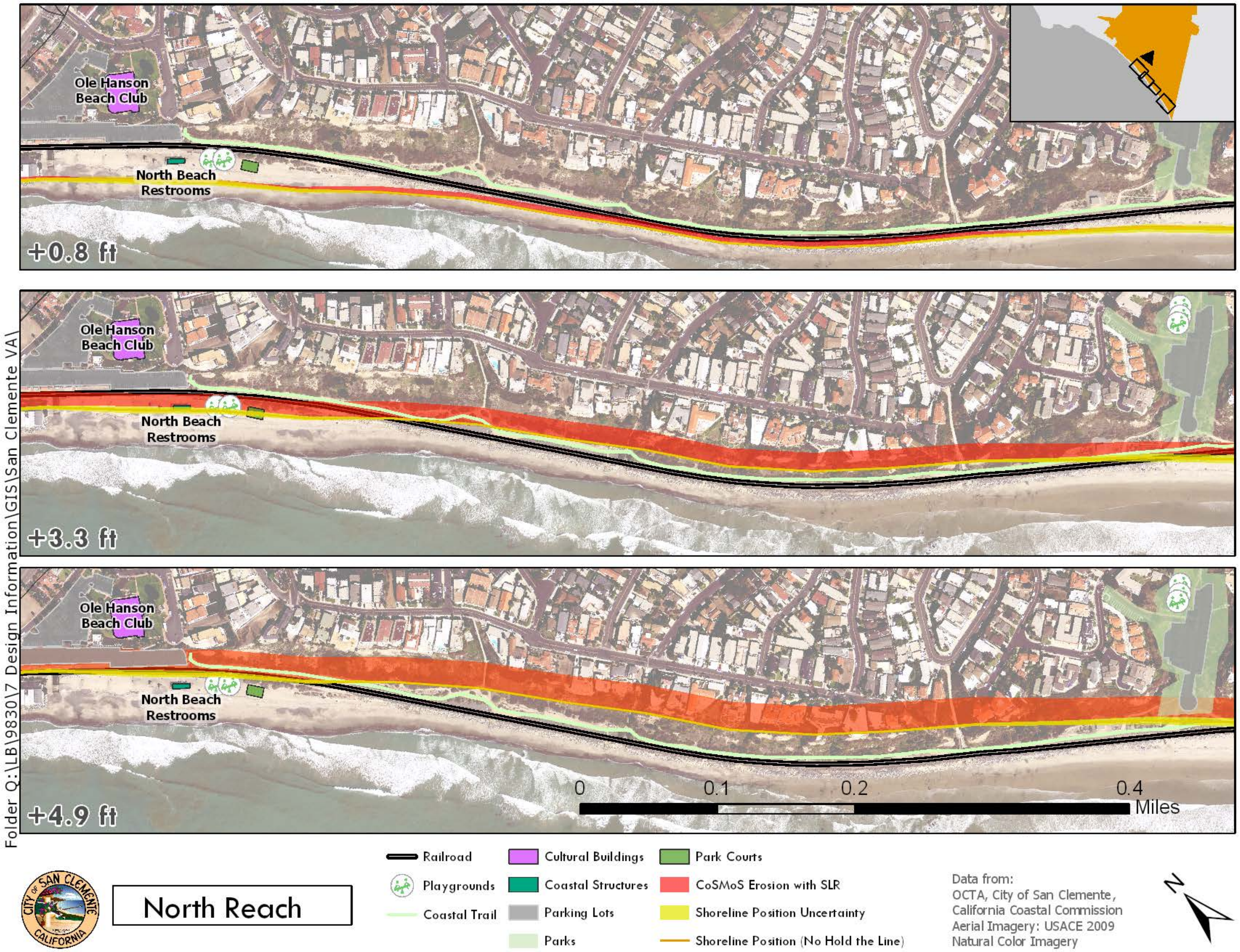


Figure 19: Shoreline Erosion Hazards, North Reach San Clemente

Figure 20: Coastal Assets Exposure, North Reach

4.5 Sea Level Rise Exposure – Central Reach

The "No Hold-the-Line, No Beach Nourishment" shoreline erosion projections are mapped along with the coastal assets for the Central Reach in Figure 21. An illustration of the exposure rating for physical assets along the Central Reach is provided in Figure 22. Exposure ratings were assigned here in the same manner applied along the North Reach.

The results indicate 0.8 ft (25 cm) of sea level rise would cause about 30 ft of shoreline erosion and an additional 20 ft of storm erosion potential near the Pier. The marine safety building has the highest non-storm exposure under this scenario due to its location on the beach. Given its history of storm damage, it may be assumed that any SLR will also increase exposure of the Pier to damage from large wave events.

Nearly all assets have moderate to high exposure under a 3.3 ft (100 cm) sea level rise scenario. The CoSMoS shoreline projections indicate the active shoreline will be at or very close to the railroad corridor during non-storm conditions impacting the coastal trail, access points such as the T-Street pedestrian bridge (Figure 44), and restrooms. The railroad is not protected with armoring along much of the Central Reach. SLR would subject the railroad to storm-related erosion in this scenario, likely triggering some type of adaptation strategy to prevent undermining and failure.

The shoreline projections for a 4.9 ft sea level rise scenario indicate the shoreline would erode landward of the railroad corridor, to the bluffs (assuming the railroad is relocated or removed from service in the future). Under this scenario the bluffs would be subject to wave action exposing the bluff-top development to erosion hazards.

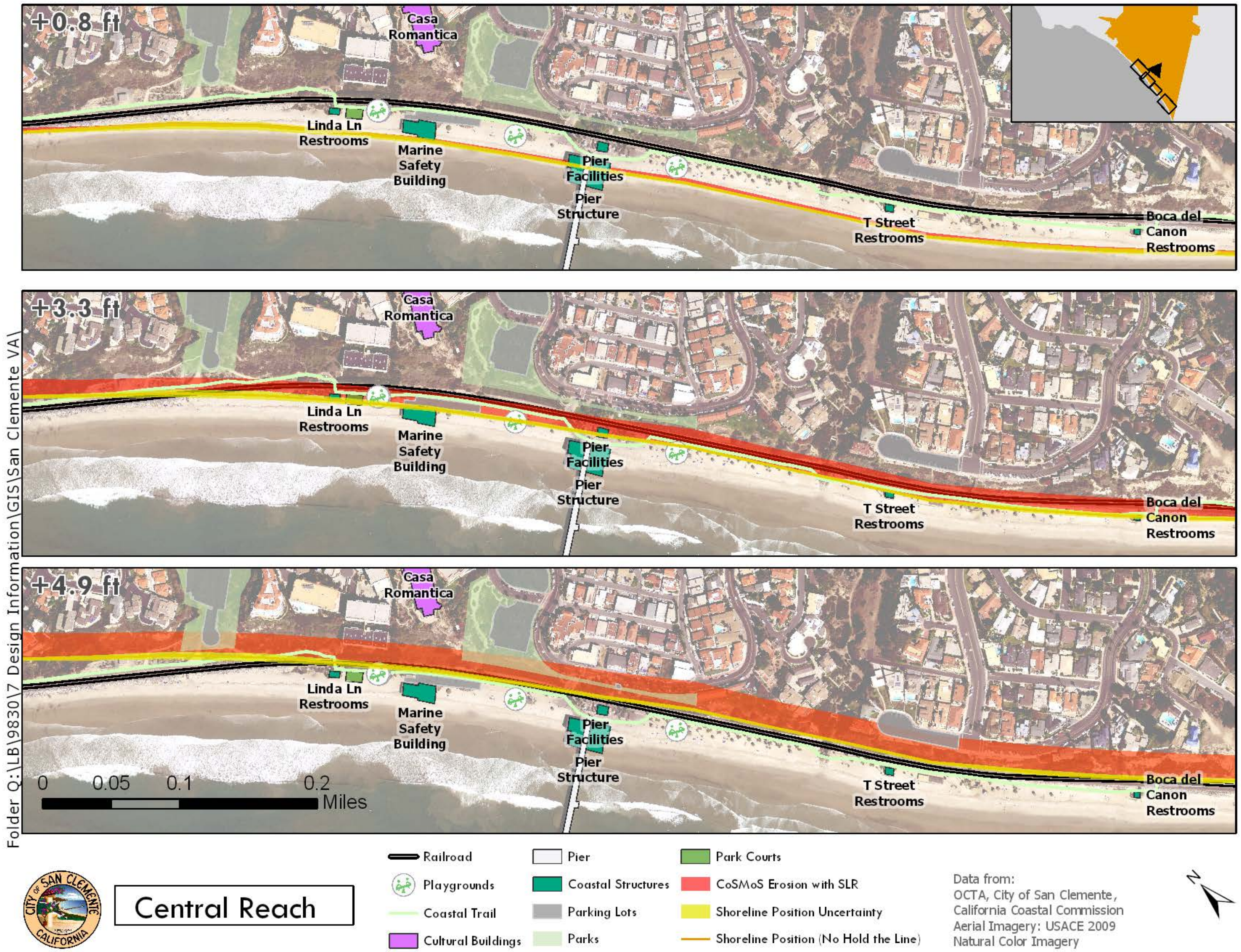


Figure 21: Shoreline Erosion Hazards, Central Reach

Figure 22: Coastal Resource Exposure, Central Reach, San Clemente

4.6 Sea Level Rise Exposure – South Reach

The “No Hold-the-Line, No Beach Nourishment” shoreline erosion projections are mapped along with the coastal assets for the South Reach in Figure 23 and Figure 24. An illustration of the exposure rating for physical assets along the South Reach is provided in Figure 25 and assume “No Hold-the-Line, No Beach Nourishment” scenario. Exposure ratings were assigned here in the same manner applied along the other two reaches.

For the 0.8-foot sea level rise scenario the sandy beach is exposed to some shoreline erosion but to a lesser degree than projected for the North and Central Reaches. However, the 3.3-foot sea level rise scenario indicates significant exposure of all assets seaward of the railroad corridor. Roughly 100 ft of shoreline erosion is predicted under this scenario along with another 50 ft of storm erosion potential. The CoSMoS shoreline projections indicate the active shoreline will be at or very close to the railroad corridor during non-storm conditions impacting the California Coastal Trail, public beach access points, and public restrooms. The LOSSAN railroad would be subject to storm related erosion in this scenario, likely triggering some type of adaptation to prevent undermining and failure.

The shoreline projections for a 4.9 ft sea level rise scenario indicate the shoreline would erode landward of the railroad corridor to the bluffs (assuming the railroad is relocated or removed from service in the future). As mentioned previously, the shoreline erosion projections assume no future beach nourishment in addition to removal/relocation of the railroad. Under this scenario the bluffs would be subject to wave action exposing the bluff-top development to erosion hazards.

Figure 23: Shoreline Erosion Hazards, South Reach, San Clemente (1 of 2)

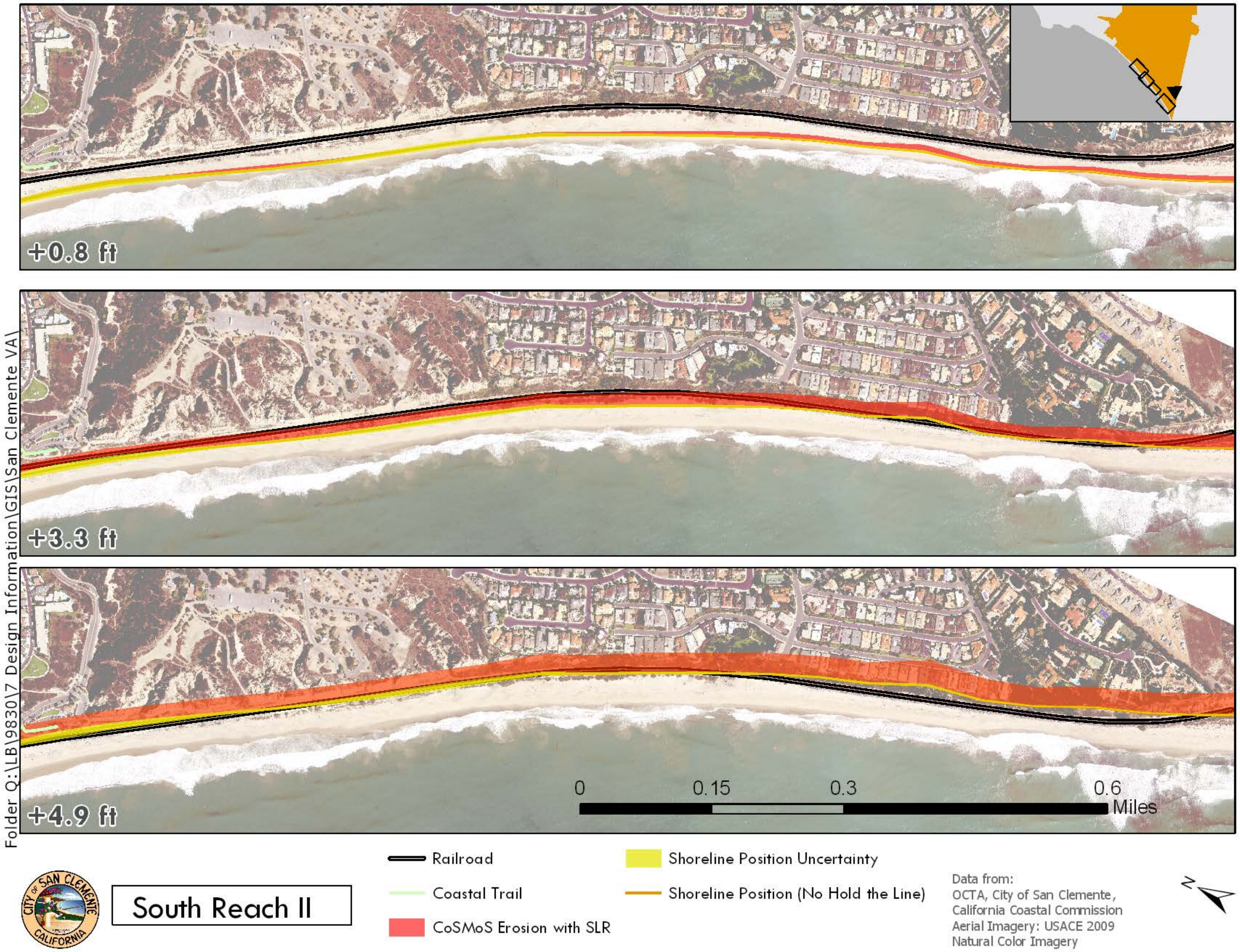


Figure 24: Shoreline Erosion Hazards, South Reach, San Clemente (2 of 2)

Figure 25: Coastal Resource Exposure, South Reach

5. Sea Level Rise Vulnerability Assessment

The purpose of this assessment is to identify potential physical impacts and their effect on coastal resources to better understand potential future local hazard conditions under a range of SLR scenarios. A resource's vulnerability to SLR is a product of:

- Exposure to hazards (i.e., shoreline erosion, coastal flooding and inundation);
- Sensitivity to hazards (i.e., potential damage or loss of function); and,
- Adaptive capacity (i.e., the ability to adapt, restore function or avoid damage).

Resiliency comes from increasing an asset's adaptive capacity by reducing vulnerability to hazards (i.e. protection). Some of the resources identified in this study have reduced vulnerability to hazards such as bluff erosion because of protections that are in place such as the LOSSAN railroad revetment.

In the case of these protective assets that have an unknown service life, this assessment looks at an asset's exposure to SLR in the event these protective assets were theoretically removed or relocated in the future. This approach allows for a preview of the worst-case long-term sea level rise vulnerability of coastal resources in the City assuming no actions are implemented by the City or by others and that a policy of managed or planned retreat resulted in removal or relocation of the LOSSAN railroad.

The results of the SLRVA are organized by resource category in the following sections. A recap of the Study approach (described in Section 1) is summarized in the four steps below.

1. Identify coastal resources and assets within the City's coastal zone
2. Choose appropriate SLR scenarios that allow for the identification of critical thresholds, as well as short-term and long-term consequences. Short term consequences refer to impacts from the 0.8-foot sea level rise scenario, expected to occur between 2040 and 2080. Long-term consequences are based on impacts from the 3.3 foot and 4.9-foot sea level rise scenarios. These scenarios represent a range of projections for the end of the century (~2100). However, the most conservative SLR projections (H++ scenario) indicate 3.3 feet of sea level rise could occur as soon as the year ~2060.
3. Use the best available models to understand the type, extent, and location of physical hazards to identified assets.
4. Assess each assets vulnerability by considering exposure, sensitivity, and adaptive capacity.

The existing railroad and revetment that traverses through San Clemente is owned and operated by the OCTA. The OCTA was recently awarded an SB 1 Adaptation Planning Grant in the amount of $461,771 from Caltrans to fund a study known as the "*Orange County Rail Infrastructure Defense Against Climate Change Plan*". The study will identify strategies to evaluate the negative effects of storm activity, increased precipitation levels, sea level rise, temperature increases, and associated climate events on the OCTA-owned rail right-of-way in Orange County, and develop strategies to ensure resilience of the transportation services and assets. OCTA has indicated it will develop *the Orange County Rail Infrastructure Defense against Climate Change Plan* that will identify vulnerable locations, assess short- and long-term mitigation measures, and conduct cost estimates. This Plan aims to build a resilient transportation system that is utilized by disadvantaged communities and military operations, as well as contributes to a thriving economy. The CCC has suggested that the City include details as to the locations and numbers of residential and commercial properties that may become subject to coastal hazards over various timeframes including conditions under which the existing rail corridor is removed and relocated. This analysis is included in Section 5.11.

CCC staff have suggested that this Study include an analysis of SLR-related vulnerabilities of the existing Capistrano Shores residential community. Consistent with the recently comprehensively updated and certified LCP LUP which designates Capistrano Shores as an Area of Deferred Certification (ADC) geographically segmented from the LCP per LUP Policy GEN-10, this analysis is not included herein at this time and may be a topic for future research.

Regional Coordination and Collaboration

It was also suggested by CCC staff that an analysis of SLR related impacts on neighboring jurisdictions such as Marine Corps Base Camp Pendleton and Dana Point be included in this City report. While the City continues to coordinate with these adjacent jurisdictions on the City's SLR analysis, both agencies are in the process of conducting their own SLR related vulnerability assessments and coastal resiliency plans which the City will review. In general, the City is highly supportive of a regional approach to adaptation planning as the effects of global climate change are not localized to a single jurisdiction and there are economies of scale and other efficiencies to be gained from a regional, coordinated approach to resiliency building.

5.1 Public Beaches and Public Trust Resources

Description:

The Public Trust doctrine provides that tide, submerged lands, and other navigable waterways are to be held in trust by the State for the benefit of the people of California. In addition to Public Trust lands (i.e., tidelands and submerged lands, from the shore out three nautical miles) there are at risk resources that include the public beach. San Clemente is known for its world class beaches. The beaches are for the most part sandy, with cases of courser sediment noted after a nourishment project in 2005 (Ghori and Swegles, 2015). Beach width in the City varies significantly seasonally and daily, due to tides from 15 ft in the north to 200 ft in the south (from 2017 aerial imagery). The beaches provide public recreation activities for residents and visitors, as well as protection for the bluffs and railroad behind them. The entirety of the beach experienced considerable erosion in the 2016-2017 winter storms and require nourishment to maintain current conditions. Two highly popular weekend events take place annually: Sea Fest and the Ocean Festival, which rely on the pier and beach for activities. San Clemente City Beach and State Beach have combined annual attendance of 3,103,581 and are responsible for over $67 million in annual spending and over $130,000 in annual city tax revenue (OCCRSMP, 2012). The Pier Bowl (left) and south beaches (right) are shown below.

Vulnerability Summary:

SLR will worsen already chronic erosion rates resulting in beach loss throughout San Clemente. With a decreasing natural supply of sediment, the narrow beaches are very sensitive to storms. The effects of storms will increase in magnitude with higher water levels. Beach nourishment will help to maintain beach width in the short term, but higher water levels will make sandy beaches very difficult to retain impacting the recreational opportunities available on the dry beach areas (i.e. towel area, fire pits, volleyball courts and amenities). Access to the beach and ocean including parking, paths and trails are also expected to be affected.

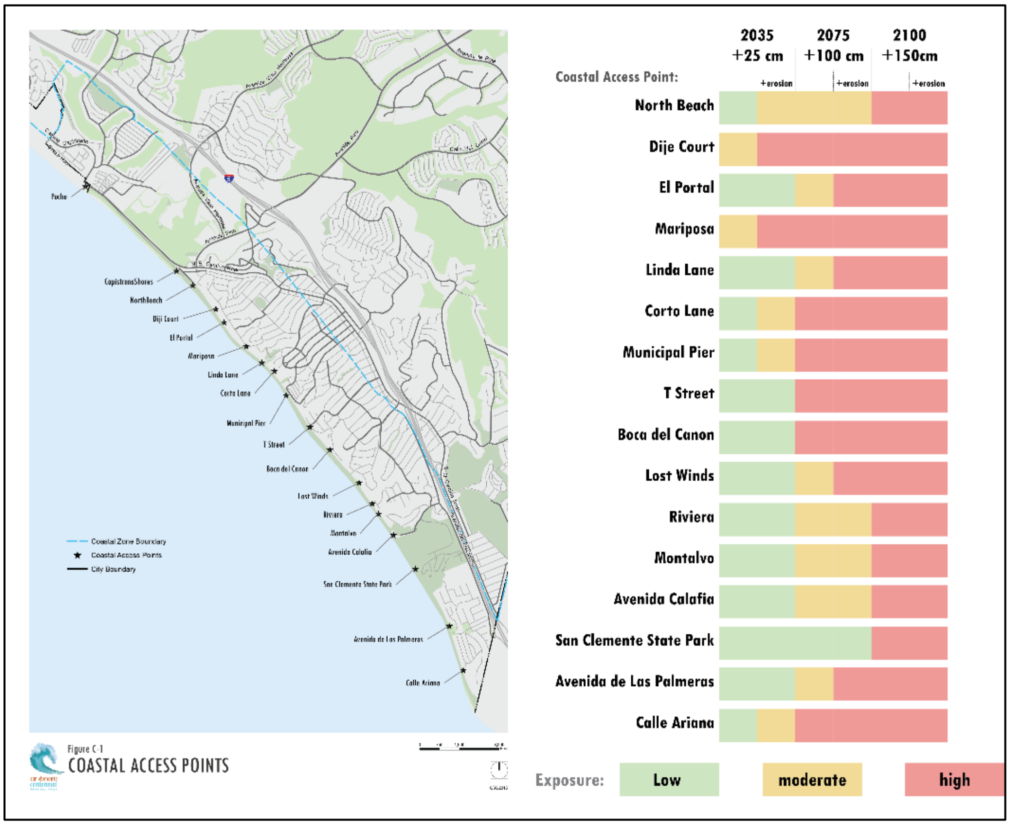
Exposure:	Sensitivity:	Adaptive Capacity:
▪ Highest exposure to erosion in North and parts of Central, risk of permanent beach loss with +3.3 ft of sea level rise under non-storm conditions.	▪ Northern reach is narrowest and sensitive to storm events paired with high tides.	▪ Beach profile will migrate landward with sea level rise but maintaining an adequate supply of sand could be difficult and costly for high rates of sea level rise.

Short-term Consequences:	Long-term Consequences: (assuming no action)
▪ Low tide only or seasonal beach in North Beach ▪ Further loss of lateral (alongshore) beach access ▪ Loss of protection to LOSSAN and bluffs landward ▪ Loss of beach recreation including surfing	▪ Near total loss of beach city-wide ▪ Beaches will be difficult to maintain even with nourishment ▪ Loss of protection from large storm events ▪ Loss of recreation including surfing ▪ Habitat changes and potential loss of species

5.2 Coastal Public Access Points

Description

There are 19 access points in the scope of this study, 15 of which are accessible by public and four of which are private. Access points vary in accessibility and consist of a mix of paved trails, steps on the bluff, railroad over- and under-crossings, and stairs to the beach. The most accessible of these points is the San Clemente Municipal Pier, which allows for semi-paved access directly to the sandy beach and pier. A list of access points and their exposure is shown below.



Vulnerability Summary

The vulnerability of public access points varies along the study reach depending on the configuration of the access path and proximity to current and future coastal hazards. The configuration of each access path is described and illustrated in Appendix A. The exposure of each access point to current and future shoreline erosion hazards is illustrated above. Dije Court and Mariposa are most vulnerable due their high exposure to potential erosion where frequent wave uprush against the railroad revetment can inhibit beach access. Below grade crossings exist at many of the popular beach access points and are often co-located with stormwater outfalls. These access points are more sensitive to SLR because the upward and landward migration of the beach profile could reduce vertical clearance and reduce stormwater conveyance capacity, both of which could inhibit access. Nearly all access points would be vulnerable under the 3.3 and 4.9 ft SLR scenarios assuming the City takes no action to enhance resiliency or adaption to SLR . Access stairways or paths located on bluffs could be exposed to erosion under the higher SLR scenarios if the railroad is relocated and no adaptation strategies are implemented to mitigate bluff erosion.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ High exposure to erosion. ▪ Below grade crossings subject to both coastal and fluvial flooding. ▪ Bluff erosion a potential long-term exposure	▪ Below grade crossings most sensitive to SLR due to beach profile shift and reduced stormwater capacity. ▪ At-grade crossings sensitive to chronic erosion even if protected by the railroad revetment.	▪ Re-configuration of below grade railroad crossings may be feasible to mitigate impacts at some locations. ▪ Long-term adaptive capacity of coastal access points will depend on how the railroad owners/managers respond or adapt to SLR.

Short-term Consequences:	Long-term Consequences:
▪ Compromised beach access in northern beaches ▪ Periodic flooding during storm events, especially at below grade crossings	▪ Low-lying access points could be impacted by erosion or seasonal hazards ▪ Below grade crossings may become inaccessible and prone to frequent flooding during coastal and fluvial storms. ▪ Coastal access points with trails on bluffs could be impacted by bluff erosion

5.3 California Coastal Trail

Description:

The California Coastal Trail (CCT) runs approximately 2 miles from North Beach to San Clemente State Beach and is valued resource for the City and CCC. The first 0.8 miles in the northern reach runs along the railroad on the landward side, then crosses to the beach side for the central reach near the Marine Safety Building. It then runs for 0.6 miles along the beach until it crosses the railroad again after T-Street. It then runs along the landward side of LOSSAN for 1 mile, crossing several small access tunnels and stormwater outflows. A portion of the trail along the North Reach is shown below. The CCT is part of a Statewide CCT network and a high City and CCC priority for implementation and protection.

Vulnerability Summary:

The first portion of the coastal trail to be affected is in the North Reach where erosion and flooding could extend beyond the railroad to the trail via the culvert near Portal Avenue. This location may be subject to storm exposure at +0.8 ft SLR and exposure to (non-storm) wave erosion around +1.5 ft according to CoSMoS shoreline projections. Maintaining continuity of the coastal trail will become increasingly difficult in the long-term as trails on the beach side (Central Reach) will be exposed to direct wave action seasonally or year-round. Relocation may be difficult due to physical space limitations, private land ownership, public easements/infrastructure and the LOSSAN right-of-way which protects the CCT.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ High, due erosion and wave attack along the Central Reach.	▪ Acute flooding may temporarily limit access and cause damage. Extended loss of continuity affects regional users.	▪ Narrow jurisdictional and physical boundaries make relocation difficult.

Short-term Consequences:	Long-term Consequences:
▪ Acute erosion or flooding	▪ Need for permanent adaption or relocation ▪ Loss of continuity for beachside portions.

5.4 Public Restroom and Picnic Facilities

Description:

There are five locations of restrooms on the beach: North Beach, near Linda Lane Crossing, south of the Pier, T-street and Boca del Canon. Additionally, there are picnic facilities on each side of the Pier and at T-Street. These facilities range in date of construction and are built on sand foundations. The T-street and Boca del Canon restrooms were recently renovated (2017 and 2015, respectively). The North Beach restrooms have already experienced scouring from strong coastal storms in 2017. The Linda Lane restroom is shown below.

Vulnerability Summary:

The North Beach restroom's history of damage is an example of the kind of exposure expected for restroom facilities exposed to potential hazards with SLR. The North Beach restroom is currently exposed to storm related erosion, with the Linda Lane restroom exposed with 0.8 ft of sea level rise. Erosion near or underneath the bathrooms could impact public safety and access for visitors. All restroom locations are vulnerable under the 3.3-foot sea level rise scenario.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ High exposure to erosion and wave damage with higher water levels.	▪ Severe erosion and wave attack could result in substantial damage (foundation undermining). Connections to wastewater lines are also sensitive to erosion damage.	▪ Low adaptive capacity for existing facilities, can be adapted with significant structural improvements or relocated out of erosion hazard zone.

Short-term Consequences:	Long-term Consequences:
▪ Damage to North Beach and potentially Linda Ln. facilities	▪ Permanent to acute damage to all facilities.

5.5 San Clemente Marine Safety Division Headquarters

Description:

The Marine Safety Division Headquarters was first built in 1968 and is an iconic coastal structure for the city. It serves as the center for San Clemente Marine Safety Division Headquarters, is approximately 5,000 square feet in size, and stores equipment for beach maintenance. The city spent approximately $100,000 to repair a steel sheet pile seawall in 2004. The structure has suffered damage from El Niño storms due to wave attack and erosion beneath the piles. The building includes parking and additional storage behind it. The Marine Safety Building is shown below. In 2019, the City anticipates implementing a repair project for this existing facility and enhancing the facility's shoreline protection system.

Vulnerability Summary:

The Marine Safety building is already at risk to erosion, wave runup and overtopping during large storms. Even small amounts of SLR will subject the building to more frequent storm damages from moderate to extreme storm events. It should be noted that the CoSMoS model used in this assessment is limited at a parcel scale, and further analysis may be required to assess site specific damage in more detail. The shoreline erosion hazards at each SLR scenario are shown in Figure 27. During winter storms the parking lot and amenities closest to the shore may be at risk at +0.8 ft SLR. This could include the adjacent Recycled Water Main and/or any connections it may have with the Marine Safety facility.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ High exposure to erosion and wave damage with higher water levels.	▪ Severe erosion and wave attack could result in substantial damage. Connections to wastewater lines are most sensitive to erosion.	▪ Low adaptive capacity for existing facility. Will need major improvements or relocation outside/above hazard zone to accommodate sea level rise of 3.3 ft or more.

Short-term Consequences:	Long-term Consequences:
▪ Increased damage during large storms due to narrower beaches and higher water levels	▪ Permanent damage and frequent wave attack with potential for flooding of first floor on extreme high tides.

5.6 City of San Clemente Municipal Pier

Description:

The San Clemente Municipal Pier is an iconic structure in the City and region. In 2016 the second largest employer in the City was Fisherman's Restaurant which is located on the San Clemente Pier, employing 260 people (City of San Clemente, 2016). The Municipal Pier (shown below) underwent a $2.9 million refurbishment in 2010 during which a large storm damaged construction scaffolding (Levine, 2010). As of February 2019, businesses currently operating on the Pier include Fisherman's Bar & Restaurant, The Crab Pot Restaurant and Beach Eatery and San Clemente Pier Grill and Tackle.

Vulnerability Summary:

Beach loss due to SLR is predicted to be greatest around the Pier. Loss of sediment, a steepening of the shoreline, and higher water levels could expose the pier deck to damage during winter storms, as wave crests could reach the underside of the main deck. A more detailed analysis is needed to assess the potential damage to the timber pier segments that have a lower deck elevation than the outer Pier segment. Increased maintenance or retrofitting of the pier could be required to maintain safety and/or function. In a +3.3 ft SLR scenario, the beach could retreat entirely past the base of the pier towards the pedestrian tunnel under the railroad as shown in Figure 27. This access tunnel sits at around +2.75 ft MLLW and could experience flooding and damage during high tides. Erosion could also undermine the nearby pavement and structures. Under +4.9 ft these hazards would intensify, and shoreline migration could expose the landward side of the railroad to erosion.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ High exposure to storm wave damage and erosion at the base of the pier.	▪ Sensitive to erosion of beach at entrance (base of pier), Timber pier deck sensitive to higher wave crest elevations.	▪ Low adaptive capacity due to cost of repair and adaptation.

Short-term Consequences:	Long-term Consequences:
▪ Potential for erosion beneath pier, increasing risk of damage to pier deck during storms	▪ Damage from storm waves, Erosion of beach behind pier, potential for temporary flooding

5.7 Historic and Cultural Resources

Description:			
Casa Romantica is a bluff top nationally registered historic building (designated in 1991) located adjacent to Parque del Mar. It is owned by the City and operated by Casa Romantica Center and Gardens, a non-profit 501(c)3. It serves as the main cultural institution of the city and is open to the public. Ole Hanson Beach Club is a nationally registered historic building built in 1928 and designated in 1981. San Clemente is within the historical territory of the Juaneño (Acjachemen) Tribe of American Indians. The group is known to have had coastal settlements in the area, though the majority of the blufftops within the coastal zone are already developed. Recent projects such as the Marblehead development have gone through archeological surveying with no findings of archeological artifacts in the development site. Four recorded archaeological sites near the coast include three shell middens, a village site, two manos, and a hammerstone in addition to an isolate (USACE, 2012).			
Vulnerability Summary:			
Nationally Registered Historic Places: ▪ Casa Romantica – designated 1991: If the railroad were to be relocated, the bluffs of Casa Romantica could be exposed to erosion under a +4.9 ft SLR scenario, posing potential risk to structural damage and erosion of garden space. ▪ Ole Hanson Beach Club – built 1928, designated 1981 (11m MLLW): This important cultural and historic site sits inland of the North Beach parking lot. While the lower range of SLR conditions +0.5-3.3 ft pose low potential exposure, +4.9 ft SLR in the CoSMoS model predicts coastal erosion up to the seaward edge of the site (assuming the LOSSAN railroad is removed). ▪ Outreach to the Juaneño (Acjachemen) Tribe of American Indians may be needed if cultural resources become impacted by geomorphological changes driven by SLR.			
Exposure:	Sensitivity:	Adaptive Capacity:	
▪ Moderate exposure due to setback from shoreline	▪ High, erosion or flood damage due to SLR could impact historic sites & cultural resources	▪ Low due to expenses of repair and historic nature of sites.	
Short-term Consequences:		Long-term Consequences:	
▪ Limited consequences		▪ Potential damage or erosion to sites[1]	

[1]**If** railroad is relocated **and** future beach nourishment is ineffective at protecting bluffs from wave attack.

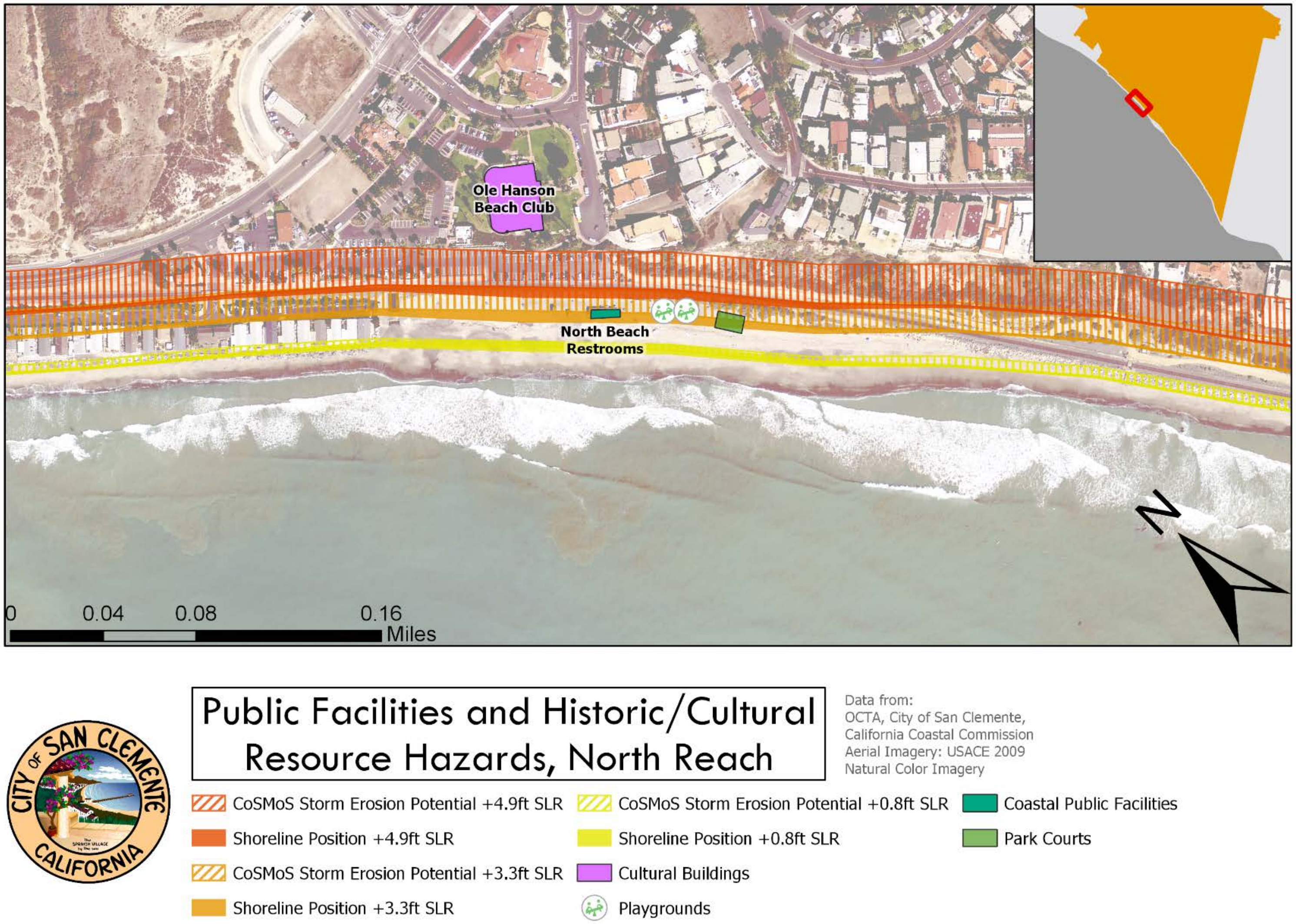


Figure 26: Public Facilities and Historic/Cultural Resource Hazards, North Reach

Figure 27: Public Facilities and Historic/Cultural Resource Hazards, Central Reach

5.8 Surfing

Description:

San Clemente is known worldwide as a cultural hub for surfing. People of all ages locally and beyond participate in the sport in San Clemente recreationally and professionally. Multiple surfing magazines and surfing organizations were founded or are currently based in the city including Surfing Magazine and the environmental advocacy group Surfrider Foundation. The City has multiple breaks along the coast including the famous T-Street Beach. The Pier is another popular surfing area as shown below.

The T-street surf site is located immediately south of the Pier. The famous surf beak is due to a permanent hard-bottom reef that rises above the seabed. Regardless of future adaptation strategies, sea level rise will shift the tide range and beach profile altering the wave breaking patterns over the T-Street reef.

Vulnerability Summary:

While beach loss at T-street could be less than other areas, according to the CoSMoS shoreline projections, a landward and upward shift of the beach profile in combination with higher water levels will alter the surf conditions at T-Street and other surf locations. Depending on the sediment source supply (i.e., fluvial or nourishment) and sandbar formation the waves may focus on a different part of the T-Street reef (likely closer to shore) with the outer reef becoming more sensitive to the tide. Further study of different adaptation strategies should consider this potential impact since T-Street is a valuable asset to the surfing and beach community.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ Highly exposed to SLR and resulting changes to the beach profile. Beach erosion could also limit public access to beach.	▪ Surf conditions are highly sensitive to changes in water level and sediment transport patterns.	▪ Low adaptive capacity due to natural formation and fixed elevation of hard-bottom reefs.

Short-term Consequences:	Long-term Consequences:
▪ Potential for seasonal beach loss, changes to surf conditions	▪ Permanent to severe beach loss ▪ Significant changes to surf conditions

5.9 Critical Public Infrastructure and Public Facilities

Description:

City and County operated infrastructure includes various stormwater inlets, outfalls, headwalls, potable water supply/conveyance lines, recycled water facilities, and gravity wastewater mains as well as electrical infrastructure supplying the pier and other coastal facilities along the public beach.

Vulnerability Summary

Stormwater outfalls could see increased sand deposition, lowering capacity and potential increased exposure to undermining from higher shoreline erosion rates. Water mains which run parallel to the beach, such as the recycled water main adjacent to the Marine Safety Building could experience damage from shoreline retreat at around 3.3 ft of SLR. Additionally, gravity mains which lie on the landward side of the railroad, face flooding during high tide events and storms, presenting exposure to the less protected landward side of the railroad.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ High exposure to stormwater outfalls due to elevated sand levels, erosion potential of some utilities at 3.3 ft of sea level rise.	▪ Stormwater outfall capacity & flood levels sensitive to higher sand elevations, utility service highly sensitive to erosion & undermining.	▪ Low adaptive capacity as utility infrastructure will require improvements to maintain function, capacity and resiliency.

Short-term Consequences:	Long-term Consequences:
▪ Potential damage to infrastructure supplying the northern beach facilities (North Beach and Marine Safety Building) ▪ Reduced capacity of smaller storm outlets leading to potential flooding & erosion for backside of LOSSAN railroad and landside development	▪ Acute to permanent damage of infrastructure ▪ Need for relocation or large-scale adaption of systems

5.10 LOSSAN Rail Corridor

Description:

The LOSSAN Rail Corridor follows an alignment along the toe of the coastal bluff and is protected by a revetment in many locations. Coastal hazards and the effects of sea level rise on coastal assets in the City will largely depend on the condition of the revetment lining the railroad corridor in the future. The railroad sits at elevations ranging from 20-25 ft NAVD88 (17.5 to 22.5 feet above mean sea level). At this elevation, the tracks are not exposed to long duration flooding, but are within the wave runup and overtopping zone. The lowest points are located at the San Clemente Station, the Pier, and State Beach and the highest are when the railroad lies closest to the bluff in the north and southern portions of the city.

Vulnerability Summary

The Northern reach of the corridor is highly exposed to SLR. At present, this segment of railroad is protected by a revetment that experiences direct wave action year-round and erosion of the backside via an opening at the W. Portal access point. The railroad itself would experience more frequent flooding and potential for damage during large wave events. Much of the potential for damage is first focused at the W. Portal Stormwater Culvert which allows further erosion landward of the railroad. Similarly, further south at the narrowest stretch, where the coastal trail is already elevated, erosion and wave attack against the riprap and railroad is predicted to be severe for sea level rise greater than 3.3 ft. The San Clemente rail station could see exposure to erosion and flooding from the limited capacity to the North Beach storm drain channel during winter storm events. If left in place at the current elevation, the railroad would likely be inoperable due to frequent flooding and erosion damage under a +4.9 ft SLR scenario unless it was protected from erosion and flooding by an engineered seawall or revetment.

Along the central reach within the city, the railroad is not protected by a revetment in places, rather a sandy beach protects it. Under a +3.3 ft SLR condition, beach loss could extend into and at points past the rail corridor. In the CoSMoS model, beach erosion could reach the rail corridor as soon as +2.5 ft SLR. Without armoring, shoreline erosion would threaten to undermine the railroad.

While the southern reaches of the railroad are protected by a revetment, shoreline migration could leave the revetment exposed to direct wave attacks starting at Calafia Beach and Boca Del Canon as soon as +1.6 to 2.5 ft SLR with potentially 100% of the revetment exposed at +3.3 ft SLR. The southern portion could see potential damage and erosion dynamics as the rest of the railroad in the other reaches. The ability of the existing revetment to withstand these erosive forces is uncertain as most of the revetment is reported to be non-engineered with varying levels of protection (USACE, 2012).

Exposure:	Sensitivity:	Adaptive Capacity:
▪ High exposure to wave attack and erosion.	▪ Highly sensitive to erosion, as undermining of railroad ballast could interrupt rail service.	▪ Low: additional rock is currently placed in critical areas, but long-term solutions could require more significant protection or relocation.

Short-term Consequences:	Long-term Consequences:
▪ Damage to railroad, potential loss of service during storm events	▪ Potential need for relocation ▪ Chronic erosion or need for additional protection ▪ More frequent service interruptions

5.11 Blufftop Residential and Commercial Development

Description:

The San Clemente coastline above the beach area is extensively developed. Approximately 90% of the blufftop extent from the North Beach recreation area to the southern City boundary contains current residential or commercial development. The remaining proportion is primarily comprised of Calafia State Park and San Clemente State Beach's blufftop camping and recreation area. Private development along the coastline is almost wholly residential except for a group of commercial parcels near the pier and state owned facilities at Calafia State Park and San Clemente State Beach. Residential parcels vary in nature from single family residences to large condominium facilities.

Vulnerability Summary

If the railroad were to be relocated to an inland alignment in the future, the bluffs underlying coastline development would be subject to coastal erosion under SLR scenarios higher than 3 feet. Limited blufftop areas would be at risk at +3.3ft SLR, primarily due to intensified erosion during storm events. Significant impacts across the full extent of the coastline would be expected at +4.9ft SLR. Sustained erosion due to wave action at the base of bluffs would induce slope failure up the bluff face, eventually causing retreat of the blufftop and potentially undermining the foundations of existing development. Bluff erosion therefore presents a considerable threat to the safety of any development situated on the bluff. Figure 28 to Figure 31 illustrate predicted shoreline and bluff top erosion at +4.9ft SLR and potentially affected parcels, assuming no other intervention. A quantitative summary of parcels impacted is provided in Table 4.

Table 4: Blufftop Parcels Vulnerable at 4.9 feet SLR*

Type	Number of Parcels
Residential	166
Commercial	2
Mixed-Use	9
Public	5
Open Space	10

Exposure:

- Low exposure due to setback from shoreline and location behind current rail corridor.

Sensitivity:

- High sensitivity for developed parcels since erosion could undermine building foundations.

Adaptive Capacity:

- Low adaptive capacity due to high cost of adaptation strategies and limited options available for relocation.

Short-term Consequences:

- Limited consequences

Long-term Consequences:

- Potential bluff instability and permanent damage to developments near bluff face if the railroad is relocated and future beach nourishment, or other adaptation strategies are ineffective at protecting bluffs from wave attack

Figure 28: Blufftop Development Hazards (Area 1 of 4)

Blufftop Development Hazards (Area 2 of 4)

Data from:
OCTA, City of San Clemente,
California Coastal Commission
Aerial Imagery: USACE 2009
Natural Color Imagery

Bluff Top +4.9ft SLR
Approx. 2010 Bluff Top
Shoreline Position +4.9ft SLR
CoSMoS Storm Erosion Potential +4.9ft SLR

Parcel Type
Commercial
Open Space
Public
Residential
Mixed-Use

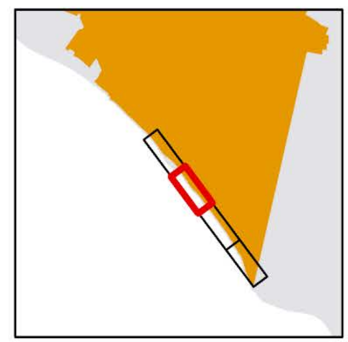


Figure 29: Blufftop Development Hazards (Area 2 of 4)

Figure 30: Blufftop Development Hazards (Area 3 of 4)

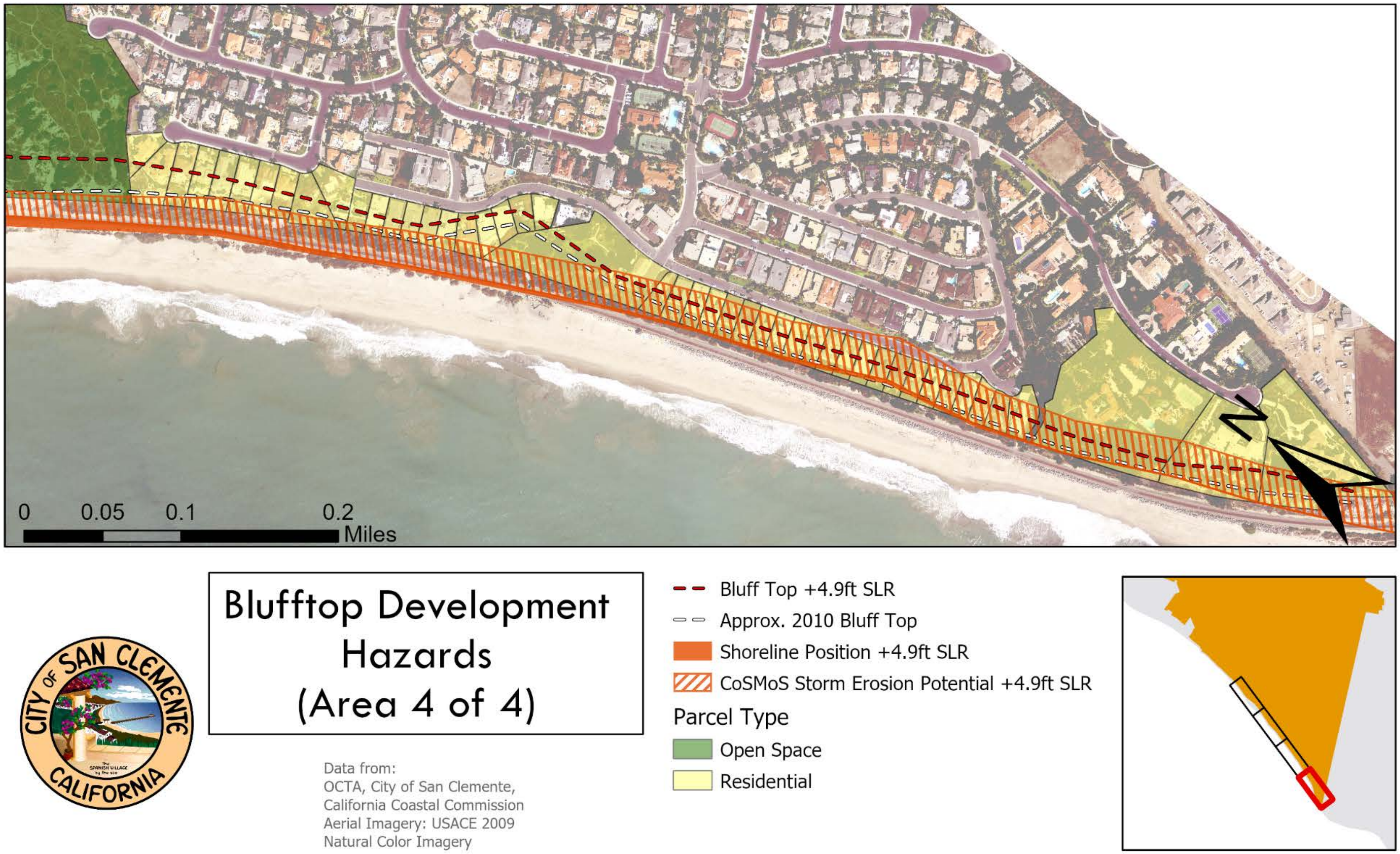


Figure 31: Blufftop Development Hazards (Area 4 of 4)

5.12 Transportation Infrastructure / Public Roadways

Description:

Much of the city's transportation infrastructure within the scope of this study is at elevations high enough to be considered a low concern with respect to sea level rise. Most roads in the City (except those noted below) are above an elevation of ~25 ft NAVD and setback from the potential SLR affected areas and therefore are a low concern for SLR impacts. The lower lying roads are found at El Camino Real in the North Reach, in the San Clemente Pier Bowl area, Boca del Canon and near Calafia State Park. This section includes traffic signals or electric infrastructure associated with the city's road network. No current bike infrastructure (including bike lanes) is within the exposed areas in the range of SLR considered for this study.

Vulnerability Summary:

Low lying, coastal roads such as El Camino Real, Avenida Victoria, Boca del Canon (private), Plaza A La Playa and Avenida Calafia could be exposed to shoreline migration in the case of a relocated railroad and sea level rise greater than 4.9 ft. Damage to these roads presents access and safety concerns. Additionally, the Avenida Victoria - Coronado bus stop on the OCTA 91 line would be at risk and is one of the central lines providing access to the San Clemente Pier Bowl area.

Additionally, the North Beach parking lot sits lower than the railroad by 1-4 ft which leaves it exposed to flooding during large storm events in a +3.3 ft SLR condition. If the railroad is re-aligned in the future, the exposure of this parking lot would need to be re-evaluated.

El Camino Real, along the North Reach study area, is one of the lowest lying (20-23 ft NAVD88) roads in the city. According to CoSMoS erosion projections the road is not exposed to shoreline erosion for the scenarios evaluated. Exposure to erosion or flooding for higher SLR increments would depend on how development seaward of the road (LOSSAN railroad, Capo Shores and Shorecliffs Beach Club) adapts to future coastal hazards.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ Low: most roads are elevated and setback from projected hazards	▪ Medium to high, if roads were unprotected from storm action, erosion could lead to instability and permanent damage.	▪ Low due to cost of road repair or relocation.

Short-term Consequences:	Long-term Consequences:
▪ Limited short-term consequences; intermittent flooding or inundation	▪ Potential for beach and bluff erosion impacts for sea level rise greater than 4.9 ft if the railroad is relocated and future beach nourishment is ineffective at protecting bluffs from wave attack.

5.13 Environmental Resources/Environmentally Sensitive Habitat Areas (ESHA)

<table>
<tr><th colspan="6">Description:</th></tr>
<tr><td colspan="6">San Clemente’s shoreline is predominately sandy beach bordered by the railroad corridor and coastal bluffs, with sparse rocky outcroppings offshore (USACE, 2012). Subtidal habitats include the federally designated habitat areas of particular concern (HAPCs) canopy kelp beds and rocky reefs as well as soft-bottomed reefs, and surfgrass beds (OCCRSMP, 2012). Offshore resources are beyond the jurisdiction of the City and beyond its management capabilities to plan for. Above the beach, coastal scrub and developed land dominate, with coastal dunes present in the southern reaches of the City. Stands of eucalyptus trees along and within Calafia Canyon constitute monarch butterfly ESHA. Sensitive biological resources are found in the study area that can be potentially affected by sea level rise.</td></tr>
<tr><th colspan="6">Vulnerability Summary:</th></tr>
<tr><td colspan="6">Detailed exposure of these biological resources is not within the scope of this study; however, the idea of coastal squeeze presents an issue for the coastal habitats of the area. Without the ability for a potential migration of the shore due to armoring such as the LOSSAN revetment, the gradient of subtidal, intertidal, and bluff habitats become squeezed. This means a loss of the ecologically important intertidal habitat (Addessi, 1994). A notable species dependent on sandy intertidal beaches is the California grunion, Leuresthes tenuis, which deposits eggs in the exposed beach during mass spawning events lasting from March-August (Clark, 1925). Subtidal habitats such as kelp beds and surfgrass beds are vulnerable to changes in substrate and depth and while there is not much research on effects of sea level rise on these habitat types, the impacts of sediment management and beach nourishment can be found in the USACE 2012 Main report. If coastal bluffs were to be allowed to erode, research suggests that the habitat type would successfully reestablish or invade new areas (Westman, 1982).</td></tr>
<tr><th colspan="2">Exposure:</th><th colspan="2">Sensitivity:</th><th colspan="2">Adaptive Capacity:</th></tr>
<tr><td colspan="2">▪ High exposure to erosion of sandy beach habitat</td><td colspan="2">▪ Endangered or protected species highly sensitive to loss of habitat</td><td colspan="2">▪ Medium to high (species/habitat dependent), some additional habitat can be created through sand nourishment, artificial reefs, or managed retreat</td></tr>
<tr><th colspan="3">Short-term Consequences:</th><th colspan="3">Long-term Consequences:</th></tr>
<tr><td colspan="3">▪ Loss of sandy beach in Northern portions of San Clemente</td><td colspan="3">▪ Loss of sandy beach habitat, shift in subtidal habitat including rocky and sandy bottom ecosystems</td></tr>
</table>

5.14 Scenic Resources

<table>
<tr><th colspan="6">Description:</th></tr>
<tr><td colspan="6">The city has identified several scenic vistas and view corridors in its Centennial General Plan and LCP which center around North Beach and the Pier Bowl area. These public view corridors center around the City's coastal canyons and beach areas.</td></tr>
<tr><td colspan="6">Vulnerability Summary:</td></tr>
<tr><td colspan="6">Loss of sandy beach due to erosion could affect the aesthetic quality of San Clemente's beaches. Views of the ocean and offshore areas would not be impacted by SLR.</td></tr>
<tr><td colspan="2">Exposure:</td><td colspan="2">Sensitivity:</td><td colspan="2">Adaptive Capacity:</td></tr>
<tr><td colspan="2">▪ High exposure to beach loss.</td><td colspan="2">▪ Low to Medium, unknown how beach loss will appear aesthetically. The value of views is resilient to seasonal changes in beach quality and form as the primary scenic quality is tied to the visual presence of the ocean.</td><td colspan="2">▪ Medium, loss of sandy beach can be alleviated with beach nourishment though with greater SLR, sustainability of an effective nourishment program could be difficult.</td></tr>
<tr><td colspan="3">Short-term Consequences:</td><td colspan="3">Long-term Consequences:</td></tr>
<tr><td colspan="3">▪ Loss of sandy beach in narrow beaches</td><td colspan="3">▪ Loss of beach or potentially seasonal beaches throughout city.
▪ Potential bluff erosion could also impact aesthetic character[1]</td></tr>
</table>

[1] **If** railroad is relocated **and** future beach nourishment is ineffective at protecting bluffs from wave attack.

5.15 Saltwater Intrusion

Description:			
As sea levels rise, the fresh-salt groundwater interface is pushed upwards. Over-pumping of groundwater can amplify this effect by pulling seawater inland. The City has already experienced salinity issues in its groundwater in the past, for example a groundwater well for public use was no longer used after 1958 due to seawater intrusions. The City's Urban Water Management Plan notes that as of 2015, one of two wells in the City (well No. 8, located outside of the Coastal Zone and near Vista Bahia Park) appears to display initial stages of saltwater intrusion (Arcadis, 2015).			
Vulnerability Summary:			
Higher groundwater can cause shoaling where groundwater is already at shallow depths (Hoover et al., 2017). Additionally, rises in groundwater in bluff top areas can affect the erosion and failure rates of coastal bluffs (Young, 2017). According to the San Clemente 2015 Urban Water Management Plan (UWMP), the City's main source of water supply is imported water from Metropolitan Water District of Southern California. Imported water is supplemented by local groundwater extracted from City owned wells, and recycled water produced at the City's recycled water treatment facility. Ground water accounts for less than 10% of the City's water supply and in the future the water supply mix is expected to shift to more recycled water use as a result of the City's recycled water treatment facility expansion. The majority of the City's water comes from the Metropolitan Water District of Southern California, which sources water from outside of the region. Sea level rise poses risks to other sources such as the Delta in Northern California where the Metropolitan Water District obtains some of its water. In addition, the San Diego County Water Authority is studying a desalination project to be located at the southwest corner of Marine Corps Base Camp Pendleton. The initial project would be 50 MGD with increments to a maximum capacity of 150 MGD. The project is currently in the feasibility study stage and would be resilient to climate change. Local agencies have shown an interest in the project including the South Coast Water District which is also in the process of permitting a pilot desalination plant at Doheny Beach. The proposed project is projected to produce 5 mgd of potable water with the ability to expand as a regional facility to 15 mgd.			
Exposure:	Sensitivity:	Adaptive Capacity:	
▪ Unknown	▪ Unknown and recommended for further research / analysis in the 2020 UWMP update.	▪ Groundwater injection/pumping can be used to manage the effects of sea level rise on groundwater tables.	
Short-term Consequences:		Long-term Consequences:	
▪ Unknown		▪ Unknown	

5.16 Socioeconomic Impacts and Environmental Justice

Description:
The beaches of San Clemente provide significant tax revenue for the City and county. Due to a narrow coastal typology, beach loss becomes a direct threat to these major economic drivers. Residents, and non-residents such as workers and tourists whose work or visit is related to industries such as hospitality, food services, retail, and others dependent on San Clemente's 3 million annual beach attendance that could be economically vulnerable with rising seas. For example, in 2016 the second largest employer in the City was Fisherman's Restaurants which is located on the Pier, employing 260 people (City of San Clemente, 2016). The 2018 OPC SLR report defines "environmental justice" as follows: The structures, policies, practices, and norms resulting in differential access to the goods, services, and opportunities of society by "race." It is normative, sometimes legalized, and often manifests as inherited disadvantage. Examples include differential access to quality education, sound housing, gainful employment, appropriate medical facilities, and a clean environment. The State is encouraging cities to prioritize actions that promote equity, foster community resilience, and protect the most vulnerable and to explicitly include communities that are disproportionately vulnerable to climate impacts in adaptation planning.
Vulnerability Summary:
Unlike in low lying cities where SLR typically threatens homeowners to flooding, SLR in San Clemente first threatens the public resource of the sandy beach. The recreational, habitat and coastal access benefits provided by the sandy beach will be most vulnerable to sea level rise. Depending on management and adaptation strategies, the erosion of bluffs could put property owners and renters at risk to structural hazards. SLR may require the City to acquire new access points, parks, or easements in the case of erosion. Additionally, the LOSSAN rail corridor presents difficult trade-offs between regional and local environmental impacts. The corridor's position along the narrow beach zone has major local impacts on current and future coastal dynamics in the City while also having a large regional importance by connecting the larger Southern California metropolitan areas. In cases of a hold the line management approach along the rail corridor, most of the beaches could disappear completely, versus alternative scenarios which may require a realignment of the railroad inland. While a hold the line (protection) approach would serve the railroad and resources landward of the railroad there would be adverse effects on the beach and surfing resources. Coordination with OCTA and other stakeholders on further analysis of these local and regional costs, benefits and trade-offs would help inform the adaptation planning process. None of the 11 affordable housing properties in the city are directly threatened by erosion due to SLR, though the larger economic impacts of different adaptation or management scenarios could be considered to assess the impact to socioeconomically vulnerable populations.

Exposure:	Sensitivity:	Adaptive Capacity:
▪ High beach loss reduces ability for low cost public access and recreation in the City	▪ High impact to economy and region	▪ Low to medium, beaches can be nourished, and railroad can be relocated to mitigate these impacts.

Short-term Consequences:	Long-term Consequences:
▪ Beach loss, loss of recreation capacity and revenue	▪ Potential changes to regional transportation networks and further loss of revenue and recreation

6. Range of Adaptation Strategies

This section considers two options from each end of the adaptation planning spectrum. One option below assumes a "Hold-the-Line" strategy is implemented to protect the existing railroad corridor with a seawall or revetment. The other option represents a "Managed Retreat" approach and assumes relocation or removal of the railroad allowing the beach to migrate landward in response to sea level rise and changing coastal dynamics. This simple comparison is intended to facilitate a more in-depth discussion and analysis of the potential impacts and trade-offs resulting from adaptation strategies designed to mitigate sea level rise impacts. In reality, there is a wide range of possible adaptation strategies to reduce the impacts and vulnerabilities described in Section 5. A comprehensive list of these strategies is provided in the CCC SLR Policy Guidance document (CCC, 2015).

The CoSMoS shoreline projections indicate that 3.3 ft (100 cm) of sea level rise would result in over 100 ft of shoreline retreat plus 50 ft of storm erosion potential which puts the active shoreline up against the railroad corridor. This sea level rise increment presents a key threshold where the railroad would likely be subject to constant wave action requiring some type of adaptation to maintain reliable service. The form of this adaptation (i.e., additional revetment, beach nourishment, elevating the railroad, removal of the railroad etc.) would control the landward extent of SLR hazards and likely result in different thresholds beyond 3.3 feet of SLR. Although the City has limited influence over adaptation options pursued by the railroad owner, the vulnerability of coastal assets in San Clemente depend upon how this corridor is managed in the future.

6.1 Hold the Line (Protect)

With a hard line along the LOSSAN rail corridor throughout most of the coast the first impacts the city will experience with SLR can be characterized as "coastal squeeze." Coastal squeeze can be defined as the process by which sea level dependent physical, cultural, or biological areas are pushed landwards with SLR but are prevented from natural landward migration due to a protected or non-erodible structure. For San Clemente, the dry beach and intertidal zone (and assets dependent on these areas) are at risk of permanent loss due to "coastal squeeze" throughout the study area. Coastal squeeze at Mariposa Point is shown in Figure 32.

Figure 33 depicts the narrowing and eventual loss of the dry beach and intertidal zones with progressive amounts of sea level rise assuming the LOSSAN railroad will be protected in place to Hold-the-Line. In addition to loss of beach habitat, there would be significant impacts to beach access, recreation opportunities, surfing conditions and the beach centered tourism economy. The sea level rise threshold for these impacts to occur varies along the coast. Along portions of the North Reach (Mariposa Access) the effects of coastal squeeze are visible today with the shoreline up against the railroad revetment. CoSMoS projections indicate this type of "coastal squeeze" would occur throughout the City with 3.3 ft of sea level rise. Recent sea level rise science indicates that this could occur in the City as soon as 2060 (worst case) or not until 2140 (median probability). However, other variables such as sediment supply, storm events and El Niño patterns could result in lasting coastal squeeze impacts earlier than this time horizon.

Figure 32: Coastal Squeeze at Mariposa Point

6.2 Managed Retreat

If the railroad is relocated or removed from service by the agencies that own, operate and manage the railroad the corridor footprint and area between the railroad and bluff could theoretically become available for public use, recreational activities and/or habitat restoration (i.e. dunes) for the short term. The shoreline would continue to retreat landward as the beach profile migrates upward and landward in response to sea level rise. This could create public safety issues to users of the public beach if the bluff face becomes unstable. As the beach migrates the Marine Safety Building, public utility related infrastructure, the California Coastal Trail and other coastal amenities (public restrooms, picnic areas etc.) would need site specific adaptation measures to remain functional. However, the space made available by relocation of the railroad corridor would present opportunity for relocation of these amenities. The additional 50-100 ft of beach area would also make the sandy beach more resilient to storm induced erosion and littoral sediment supply deficits in the near term (SLR ~0.8 ft). An illustration of the beach profile evolution under a managed retreat approach is provided in Figure 33.

Higher projections of sea level rise indicate that the negative effects of "coastal squeeze" would be a concern under the 4.9-foot sea level rise scenario. In this case the active shoreline would reach the bluffs and increase the potential for bluff erosion and undermining of bluff top development. This condition would pose a safety hazard for bluff top development and beach areas below. Recent sea level rise science projects this could occur as soon as 2080 (worst case) or not until beyond 2150 (median probability). Given this longer time horizon and the uncertainty surrounding many variables which affect shoreline position, the timing of when the bluffs would be subject to consistent wave action under a managed retreat approach is much more difficult to predict. The long-term effect of changes in littoral sediment supply, El Niño patterns and adaptation strategies (i.e. beach nourishment) implemented over this time horizon will have significant impacts on the future rate of shoreline retreat.

A managed retreat approach that involves relocation of the railroad would offer benefits to the community by mitigating impacts of coastal squeeze (beach loss) for sea level rise scenarios of less than 3.3 ft. However, this approach alone does not address the vulnerability of facilities like the Marine Safety Building and several restrooms along the back-beach areas. Many of these would require site-specific adaptation measures to be more resilient to the evolving shoreline erosion hazards.

It is anticipated that beach nourishment would still be needed under this strategy as the beaches would not naturally widen under a managed retreat scenario given the sediment deficit within the littoral cell. Public coastal access ways, parking lots and similar other public facilities would likely require some form of protection.

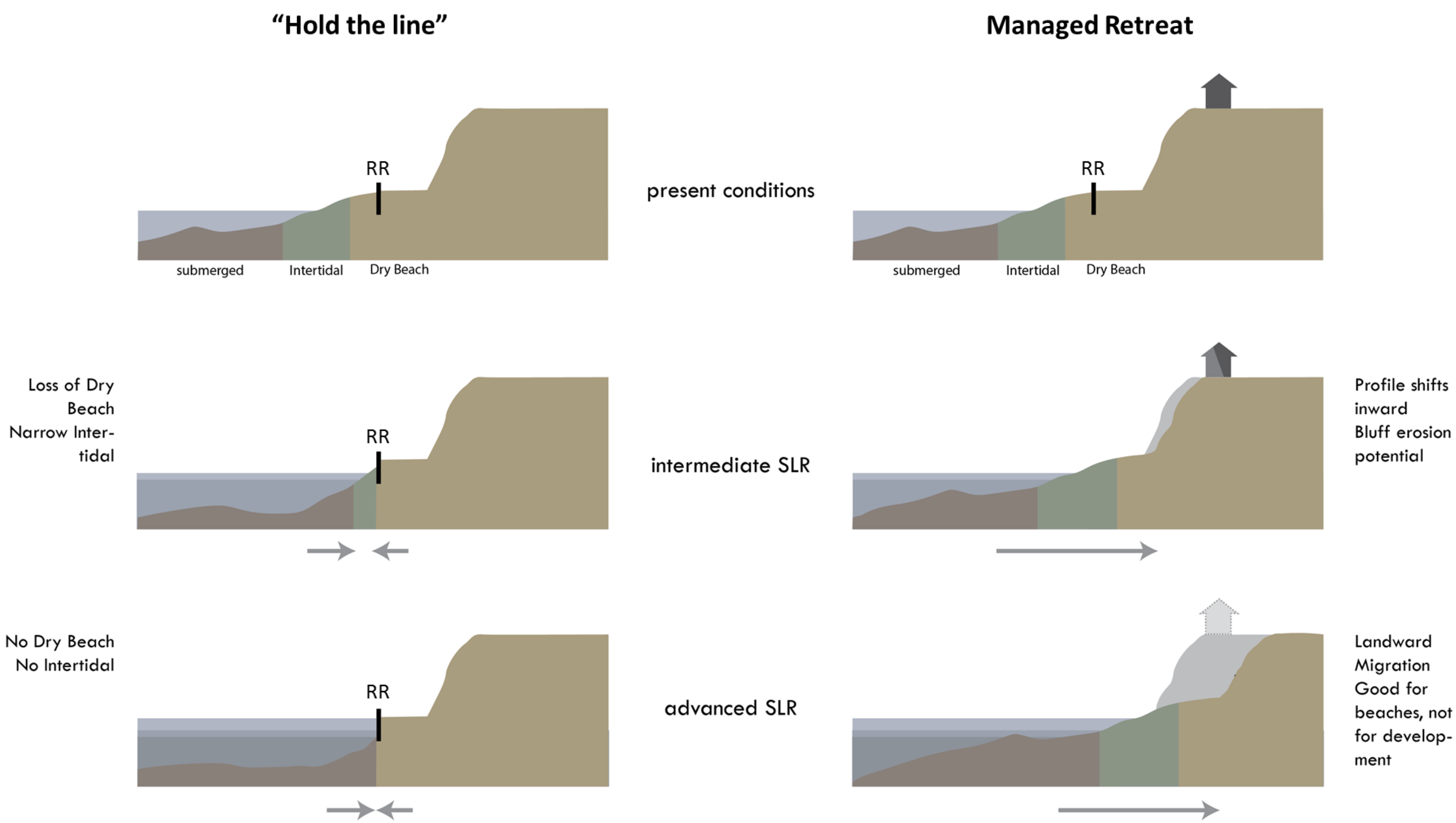


Figure 33: Illustration of Hold-the-line vs Managed Retreat Approaches

6.3 Beach Nourishment

Beach nourishment is a logical approach to offset the impacts from a retreating shoreline. A regular beach nourishment program would help mitigate the adverse effects of sea level rise on coastal resources seaward of the railroad. A detailed accounting of the cost and benefits of a beach nourishment program in San Clemente is provided in the *San Clemente Shoreline Feasibility Study (USACE, 2012).* The study identified beach nourishment as the most technically feasible and economically beneficial "recommended plan" for reducing damages from storm induced wave attack predicted to increase with chronic, long-term erosion. Other alternatives such as managed retreat, revetment & seawall, groins, offshore breakwater and submerged reefs were evaluated but not recommended due to cost, ecosystem impacts, or lack of support from the City.

The recommended plan consists of a 250,000-cubic-yard initial beach fill extending from north of the Marine Safety Building to south of T-Street to create an additional 50 feet of beach width. Re-nourishment would occur every 6 years for a total of 9 nourishments over a 50-year period. The *Feasibility Study* evaluated sea level rise of 0.7 meters (2.3 feet) and concluded only one extra nourishment over the 50-year period would be required to offset the increase in shoreline erosion due to sea level rise, indicating the plan is "unlikely to carry a significant degree of risk related to sea level rise". The addendum to the main report dated February 2012 estimated a total project cost of $161 million (FY2012 price levels) with a Non-Federal Cost share of $78.9 million.

The USACE project includes an Adaptive Management element whereby the size of future nourishment cycles could be modified as needed to address SLR and the project would not need additional federal authorizations within the first 50 years following construction.

The beach nourishment plan recommended in the *Feasibility Study* would certainly lessen the vulnerability of assets on the dry beach areas of the Pier Bowl area. Beaches to the south may also benefit as most of the sediment placed near the Pier would be transported in that direction. However, beaches along the north reach of San Clemente would not experience the same benefits from the program. If the beach nourishment program doesn't involve placement of sand along the north reach, these coastal assets will be vulnerable to the adverse effects of coastal squeeze due to sea level rise and long-term shoreline erosion. One opportunity for expanding the beach nourishment program would be to engage stakeholders such as OCTA, Caltrans, the City of Dana Point, and California State Parks whose assets would also benefit from a consistent nourishment program. San Diego Association of Governments (SANDAG) may also be a potential partner in a beach nourishment program given the City is within the same littoral cell (Oceanside) as many San Diego communities. Partnering with SANDAG on future beach nourishment projects could prove a cost-effective option to supplement the USACE program.

Beach nourishment, considered a “soft protection” or “green” strategy, is temporary by design. The *Feasibility Study* predicts the post-nourishment shoreline will erode at an average rate of 12.8 feet/year. In other words, the added beach width will begin eroding soon after placement, lasting an average of 5.5 years which is why the program incorporates regular nourishment at intervals over the 50-year federal participation period. This rate will vary based on sediment supply, wave climate and other factors driving longshore sediment transport. During stormy years and in between nourishment cycles the beach fill alone may not be sufficient to protect assets along the back beach. In order to prevent damages during these conditions, assets sensitive to undermining from erosion, such as the LOSSAN Railroad, would probably require some form of hard protection if left in place. If the railroad corridor is armored in place the coastal assets seaward of the railroad would likely be subject to coastal squeeze impacts during stormy years and between nourishment cycles.

7. Building Resiliency: Recommendations and Next Steps

Summary

The purpose of this Study is to identify areas, resources and assets in the City that may be vulnerable to rising seas in the future, so the City may begin to consider ways to improve and enhance coastal resiliency in the near term and for the long term. Although measurable SLR may not occur for several decades (i.e., 2050) planning for and implementing one or more SLR resiliency/adaptation strategies can similarly have a long lead time. Advance planning also enables the City to conduct a thorough and thoughtful process moving forward thereby optimizing the potential for mutually beneficial outcomes for the City, its residents and its visitors.

This assessment identifies several potential impacts on coastal resources in San Clemente for future SLR scenarios higher than 0.8 feet (25 cm). A resource's vulnerability to SLR is a product of:

- Exposure to coastal hazards (shoreline erosion, flooding and inundation);
- Sensitivity to coastal hazards (potential for damage or loss of function); and,
- Adaptive capacity (ability to restore function or avoid damage).

All coastal assets seaward of the railroad corridor are vulnerable to existing shoreline erosion which is predicted to accelerate with SLR. Long-term shoreline erosion coupled with storm-induced beach erosion has the potential to cause permanent damage to buildings and infrastructure seaward of the railroad revetment. Not only does beach loss threaten structures, it also has the potential to eliminate the diverse range of coastal assets dependent on the sandy beaches of San Clemente. The public access, recreational opportunities, habitat, visual, and cultural assets are foundational to the City's vibrant beach town culture enjoyed by local residents and visitors alike.

The vulnerability of some of the coastal resources, and specific assets can be reduced through adaptation measures aimed at improving hazard resiliency in the City and can be implemented on regional, local or site-specific scales. Adaptation efforts aimed at improving coastal resiliency will involve coordination with all key stakeholder groups and agencies as part of the City's efforts to understand the costs, benefits and potential trade-offs of SLR adaptation measures.

The long-term consequences of SLR pose a significant challenge locally, regionally, and globally. The impacts to the narrow sandy beaches in the City are significant for sea level rise of 3.3 feet and higher which could happen as soon as 2050-2060 under an extreme, worst case scenario. The projected beach loss would be difficult to offset with nourishment alone, especially if the rail corridor is protected in place with reinforced coastal structures. The long-term vulnerability of coastal resources will depend on what adaptation measures are implemented along the railroad corridor. The rail corridor presents a challenging trade-off between regional benefits and local impacts. The corridor's position along the narrow beach zone has major impacts on the current and future coastal dynamics in the City while also providing the regional benefit of rail service between the larger Southern California metropolitan areas. Continued coordination with OCTA and other stakeholders on further analysis of these local and regional costs, benefits and trade-offs would help inform the adaptation planning process. Additional planning is expected to occur as part of the long term SLR adaptation effort that OCTA has undertaken as part of the SB 1 Grant in 2018 and the USACE project in the future.

The existing rail corridor presents a unique opportunity as it provides both regional benefits and local benefits as it both protects structures landward of the railroad and provides the regional benefit of rail service between the larger Southern California metropolitan areas to the north and south. Coordination with OCTA on further analysis of these local and regional costs, benefits and trade-offs would help inform the adaptation planning process.

This report was based on the best available sea level rise science published by the Ocean Protection Council and consistent with California Coastal Commission guidelines. Sea level rise hazards were projected by CoSMoS 3.0, a multi-agency effort led by the USGS. The coastal processes affecting the City's shoreline are dynamic. The predictions/projections described in this report are limited by the challenges inherent in predicting future climate conditions to the year 2100, wave patterns, sediment supply and development patterns given the complexity and multitude of variables involved and the dynamic interactions therein. Climate change induced SLR is a global phenomenon and this report aims to distill the data such that it focuses on the potential, future, localized effects of SLR.

There is considerable uncertainty around the timing of SLR, future greenhouse gas emissions rates/levels, how future coastal processes may be affected, and what adaptation approaches will be applied in the future by other local and regional jurisdictions, the State and the federal government. Both locally and regionally, the most effective way for the City to address the vulnerabilities described in this report is to implement policies and programs that are flexible and can be adapted in response to SLR, future beach conditions, and future development.

Working with the USACE to implement the recommended beach nourishment program is a great first step the City has already taken toward improving the resilience of valuable coastal assets in San Clemente. In addition to a regular supply of sediment over an initial period of 50-years, this program would include detailed monitoring of littoral processes and their impact on coastal assets which will provide an extremely valuable database to inform other adaptation efforts in the City, the region and the State. Ultimately, the long-term resiliency of coastal resources will depend on what adaptation measures are implemented in the City or region to mitigate coastal hazards.

Adaptation planning is a challenging undertaking and a single jurisdiction cannot adapt to climate changes on its own. A successful process requires regional dialogue and likely State and Federal partnerships to identify, fund, and implement solutions. Challenges range from acquiring the necessary funding for adaptation strategies, communicating the need for adaptation to elected officials and staff, and gaining commitment and support from federal and state government agencies to address the realities of local adaptation challenges. Lack of resources from state, and federal agencies make it difficult for cities to make significant gains in adaptation on their own due primarily to lack of funding. Regional partnerships and dialogue between adjacent jurisdictions, Orange and San Diego Counties, Camp Pendleton and regional governments such as SCAG, OCCAG and SANDAG will be essential in developing and implementing sound regional adaptation strategies.

Building Resiliency

The IPCC defines resilience as “the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.” Although the types of hazardous events vary, the planning required to overcome them generally remains the same. It includes cooperation and coordination by governments at all levels.

Resiliency planning addresses more than the potential loss of life and property that results from a disaster. It calls on communities to reevaluate the existing infrastructure, land-use patterns, and public facilities that could be affected by a catastrophic event, particularly a repeat event.

An important factor for local governments to consider is the potential for adverse economic impact on a community. The faster an area recovers from the damage; the sooner businesses can reopen and begin the recovery period. Resilience can be achieved through a combination of effective tools and agency collaboration. By identifying vulnerabilities and adapting systems to respond to unpredictable hazards, the impacts on a community can be reduced. Most important, communities will be better suited to adapt to a changing climate and other hazards in the future.

Recommendations, Next Steps and Future Research Needs

This Study represents a continuation of the City’s efforts to build coastal resiliency and adapt to sea level rise by reducing risks and exposure to coastal hazards. There is more work to be done in the coming years. This Study recommends additional efforts intended to support City adaptation and planning efforts to increase community resiliency to SLR. Below are some of the recommended future studies based on the results of the SLR VA.

- Track short and long term SLR monitoring at local representative NOAA tide gauge stations (La Jolla and LA Outer Harbor) to better understand which greenhouse gas concentration trajectory is prevailing.
- Educate and inform the community, including visitors, about the potential future SLR related hazards on the City
- Integrate coastal resiliency planning with the next local LHMP and CAP updates
- Continue to develop and implement the USACE coastal storm damage reduction project and seek construction funding for the USACE project

- Continue to participate with OCTA in their master plan update process and SB1 Grant SLR adaptation planning efforts
- Continue to coordination with SCAG, OCCOG and SANDAG on regional SLR adaptation strategy planning and implementation funding
- Review and update the City list of CIP projects to ensure that the pier, marine safety building and other critical public facilities have future funding allocated to address potentially increased O&M, repair or replacement needs
- Work with public and private stakeholders in the City, such as State Parks and local HOAs to collaborate on future SLR adaptation measures
- Conduct a fiscal impact analysis of SLR impacts in the City to gain a greater understanding of economic risks in the future
- Conduct a cost-benefit analysis of various City preferred coastal resiliency/adaptation measures to inform decision making
- Seek funding to implement City preferred adaptation strategy implementation measures.

8. List of Report Preparers and Contributors

This report was prepared by the following individuals:

Moffat & Nichol

- Aaron Holloway, P.E., Project Manager
- Chris Webb, Senior Coastal Scientist
- Jeremy Smith, Coastal Scientist
- Troy Barnhart, Staff Engineer

City of San Clemente

- Cecilia Gallardo-Daly, Community Development Director
- Tom Bonigut. P.E., Public Works Director/City Engineer
- Bill Humphreys, Chief, Marine Safety Division
- Gabriel Perez, City Planner
- Carl Stiehl, Senior Planner
- Samantha Wylie, Recreation Specialist
- David Rebensdorf, Director of Utilities
- Leslea Meyerhoff, AICP, LCP Manager (Summit Environmental Group, Inc.)

9. References

Addessi, L. (1994). "Human Disturbance and Long-Term Changes on a Rocky Intertidal Community." Ecological Applications, 4(4), 786–797.

Arcadis. (2015). Urban Water Management Plan. San Clemente, CA

Ballard, G., Barnard, P.L., Erikson, L., Fitzgibbon, M., Moody, D., Higgason, K., Psaros, M., Veloz, S., Wood, J. 2016. Our Coast Our Future (OCOF). [web application]. Petaluma, California. www.ourcoastourfuture.org. (Accessed: Date [e.g., August 2016]).

Barnard, P.L., O'Reilly, Bill, van Ormondt, Maarten, Elias, Edwin, Ruggiero, Peter, Erikson, L.H., Hapke, Cheryl, Collins, B.D., Guza, R.T., Adams, P.N., and Thomas, J.T., 2009, The framework of a coastal hazards model; a tool for predicting the impact of severe storms: U.S. Geological Survey Open-File Report 2009-1073, 21 p. [http://pubs.usgs.gov/of/2009/1073/].

California Coastal Commission, 2015. California Coastal Commission Sea Level Rise Policy Guidance. Adopted August 12, 2015.

California Natural Resources Agency (CNRA). 2014. Safeguarding California: Reducing Climate Risk.

City of San Clemente. (2016). 2016 Comprehensive Annual Financial Report. Finance and Administrative Services, San Clemente, CA

Clark, F. 1925. "The Life History of Leuresthes Tenuis, an Atherine Fish with Tide Controlled Spawning Habits" State of California Fish and Game Commission, Fish Bulletin No. 10.

CoSMoS. USGS Coastal Storm Modeling System 3.0. https://walrus.wr.usgs.gov/coastal_processes/cosmos/index.html

Doherty, 2015. Elevated Sea Levels During 2015-2016 Strong El Nino. December 2105.

Everest International Consultants. Science Applications International Corporation. King, P. (2013) Orange County Coastal Regional Sediment Management Plan (OCCRSMP).

Ghori, I., and Swegles, F. (2015). "San Clemente eyes options for importing beach sand." Orange County Register, Orange County Register, <https://www.ocregister.com/2015/08/21/san-clemente-eyes-options-for-importing-beach-sand/> (Oct. 5, 2017).

Griggs, et al. 2005. Living with the changing California Coast. Gary Griggs, Kiki Patsch, and Lauret Savoy, et al. University of California Press, 2005.

Hoover, D. J., Odigie, K. O., Swarzenski, P. W., and Barnard, P. (2017). "Sea-level rise and coastal groundwater inundation and shoaling at select sites in California, USA." Journal of Hydrology: Regional Studies, 11, 234–249.

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., Horton, R., Little, C., Mitrovica, J., Oppenheimer, M., Rasmussen, D., . . . Tebaldi, C. (2014). Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. Earth' s Future, 383-407.

Levine, B. (2010). "High surf damages San Clemente Pier scaffolding." Orange County Register, Orange County Register, <https://www.ocregister.com/2010/01/20/high-surf-damages-san-clemente-pier-scaffolding/> (Nov. 19, 2017).

Natural Resources Agency, 2014. Safeguarding California: Reducing Climate Risk. An update to the 2009 California Climate Adaptation Strategy. July 2014.

OOCF 2017. Our Coasts Our Future http://ourcoastourfuture.org/

Patsch, Kiki and Gary Griggs. 2007. Development of Sand Budgets for California's Major Littoral Cells. Institute of Marine Sciences. University of California, Santa Cruz.

Pollard, D., & Deconto, R. (2016). Contribution of Antarctica to past and future sea-level rise. Nature, 531.

Swegles, F. (2014). "San Clemente gets 1.2 inches of rain and some messes." Orange County Register, Orange County Register, <http://www.ocregister.com/2014/12/12/san-clemente-gets-12-inches-of-rain-and-some-messes/> (Oct. 5, 2017).

USACE. (2012). San Clemente Shoreline Feasibility Study Orange County, California. United State Army Corps of Engineers, San Clemente, CA

Westman, W. E. (1982). Coastal sage scrub succession. Pages 91-99 In C. E. Conrad and W. C. Oechel, tech. coords. Proceedings of the symposium on dynamics and management of Mediterranean-type ecosystems. U.S. Dep. Agric., For. Serv., (Berkeley, Calif.) Gen. Tech. Rep. PSW-58.

Young, A. P. (2017). "Decadal-scale coastal cliff retreat in southern and central California." Geomorphology, 300, 164–175.

Appendix A – Existing Coastal Access Points (Public and Private)

Public Access Point: Pochè

The location of Access Point 1 is shown in Figure 34. This is the northernmost beach access in the City, serving beaches in both the cities of San Clemente and Dana Point. The beach nearest the drainage outlet and at the southernmost end of Dana Point is owned and operated by the County of Orange. The beach beginning at the northernmost City limit and toward the south is privately owned with its use restricted to residents of the Shorecliffs community and their guests. Pochè Beach is a popular surfing and body boarding area. Public access is allowed seaward of the mean high tide line and in the Dana Point jurisdiction of the beach area, just north of the private portion of the beach owned by the San Clemente Shorecliffs Beach Club Association. Public access to the beach follows the signalized intersection across Pacific Coast Highway to a catwalk under the rail road tracks and to the beach.

Figure 34: Public Access Point: Pochè

Private Access Point 2: Capistrano Shores Mobile Home Park

Refer to 1996 LUP for description. Capistrano Shores is now an Area of Deferred Certification and was excluded from the San Clemente LCP LUP (2018) per LUP policy *GEN-10: Applicability of the LUP to Capistrano Shores Mobile Home Park. The version of the LUP last certified in 1996 shall continue to apply to the Capistrano Shores mobile home park community, and subsequently-certified LUP policies and IP standards (including any LUP policies certified on the same date that this LUP policy was certified) shall not apply to Capistrano Shores until an LCP amendment which specifically addresses the mobile home park community has been certified, at which time the LUP policies and IP standards set forth in that Capistrano Shores-specific LCP amendment shall apply to the Capistrano Shores mobile home park community instead.*

Figure 35: Private Access Point: Capistrano Shores Mobile Home Park

Public Access Point: North Beach

North Beach, one of the principal beach access points in San Clemente, is located in this area. North Beach, as its name indicates, is the northern most public beach in the City. Vehicular access to North Beach is from El Camino Real to Avenida Estacion or Boca de la Playa, where several public parking areas can be reached. A parking lot with metered parking, as well as on-street metered, and non-metered spaces are available. There are approximately 345 parking spaces available at this location, 107 are located in the off-street parking lot, 149 on Avenida Estacion, 22 on Avenida Pico, 33 On Boca De La Playa, and 34 on Avenida Deshecha.

North Beach is the location of the City's Metrolink train station. The Metrolink station shares 150 parking spaces with beach and recreational parking. Approximately 100 spaces are reserved for recreational and beach parking only. The station includes a platform with three canopies designed in a Spanish Colonial Revival motif. In the future the City is considering adding additional public parking on the City owned vacant lot along North El Camino Real.

The beach itself is reached by crossing the railroad right-of-way at-grade crossing with safety controls at the southern end of the Avenida Estacion parking area. This is also the trailhead for the northern point of the San Clemente Beach trail, which runs 2.3 miles south to Calafia Beach.

Beach amenities maintained by the City include picnic tables, a snack bar, restrooms, shower, fire pits, volleyball courts, and a children's play area. North Beach is a family-oriented beach that experiences heavy use in the summer. The beach connects with the publicly owned two acres of the Ole Hanson Beach Club located on the bluff at the southeastern portion of this area. The Ole Hanson Beach Club contains picnic benches, a 25-yard lap pool, a wading pool a recreation building (the Ole Hanson Beach Club), and a lookout point which affords a panoramic view of the coastline. The Beach Club is a historic building (designated on the National Register of Historic Places) that is owned and operated by the City. The building is used for a variety of community and recreational activities, and it is available to be rented for weddings, social and other special events. The design requirements of the area encourage a pedestrian oriented "village atmosphere." Retail shops, gift shops, restaurants, hotels, bed-and breakfast inns, entertainment, and residential units on upper floors are all uses allowed under the plan. Public improvement projects envisioned for North Beach include the establishment of a multi modal transportation center, landscape and streetscape improvements, directional signs, PCH improved class I bike path, median and landscaping from North Beach to Camino Capistrano.

In addition to Access Point 3, there are three other access points within the Pico/Palizada area designated as Access Points 4, 5, and 6 (see Figure 37, Figure 38, and Figure 39). They are similar to one another in that they primarily serve adjacent residential areas, have very limited on-street parking, and require the use of steep stairways and/or ramps to reach the beach.

Figure 36: Public Access Point: North Beach

Public Access Point: Dije Court (204 Beach)

The Dije Court access is located at the termination of Dije Court at Buena Vista. The access connects to the beach trail "Two-O-Four" (204) beach via a steep stairway descending from a 100-foot bluff. The beach is accessed by an at-grade crossing with safety warning and control devices with stairs that lead down the rock revetment to the beach. There are no public amenities due to the narrow beach area. This is one of the more popular surfing beaches in the City.

Figure 37: Public Access Point: Dije Court (204 Beach)

Public Access Point: El Portal (204 Beach)

The El Portal access is located at the intersection of West El Portal and Buena Vista. A series of stairways and ramps down a narrow canyon lead to "204 Beach." The area at the top of this access provides an ADA accessible viewing area and picnic table with a panoramic view. The beach access via an at-grade crossing with safety warning and control devices and by a drainage channel under the railroad trestle. There are no public facilities on the beach.

Figure 38: Public Access Point: El Portal (204 Beach)

Public Access Point: Mariposa

The Mariposa access is located at the junction between West Escalones and West Mariposa. Access from Buena Vista to the Mariposa access point entrance is provided by a narrow easement through a property located at 254 West Escalones that fronts both Buena Vista and Mariposa/W. Escalones. Mariposa beach is accessed by a 300-foot concrete ramp down a narrow canyon which connects to the beach trail and a below grade crossing under the railroad to access the beach. There are no public facilities on the beach; and because Mariposa is a point, the beach sand is depleted in this area. West Reef, a popular fishing and diving area, is located approximately one-third mile offshore in front of this access.

Figure 39: Public Access Point: Mariposa

Public Access Point: Linda Lane Park

Linda Lane Park was constructed by the City of San Clemente in 1975. The park facilities provide excellent parking and beach recreation opportunities. There are approximately 131 parking spaces in the Linda Lane area. Recreation facilities within the park include a children's play area and a picnic area. The recreational facilities on the beach, coined "Second Spot" by the locals, include two volleyball courts and restrooms. Vehicular access to Linda Lane Park and beach access point is provided by Linda Lane itself (which is one way westbound). Beach and park users exit via Mecha Lane (one way northbound), which intersects Avenida Marquita.

The beach access is by a large storm drain tunnel under the railroad right-of-way. There is also an approved public access way stairway that leads from Arenoso Lane at the top of the coastal bluff down to Linda Lane Park and a public viewpoint from Linda Lane Park.

Figure 40: Public Access Point: Linda Lane Park

Public Access Point: Corto Lane

Corto Lane access is located on Corto Lane, a short street with a cul-de-sac at the end. The access is located between two large condominium projects and leads to a long stairway that makes its way down the coastal bluff. The beach access is an at-grade protected pedestrian railroad crossing. This access point leads to the beach called "Second Spot".

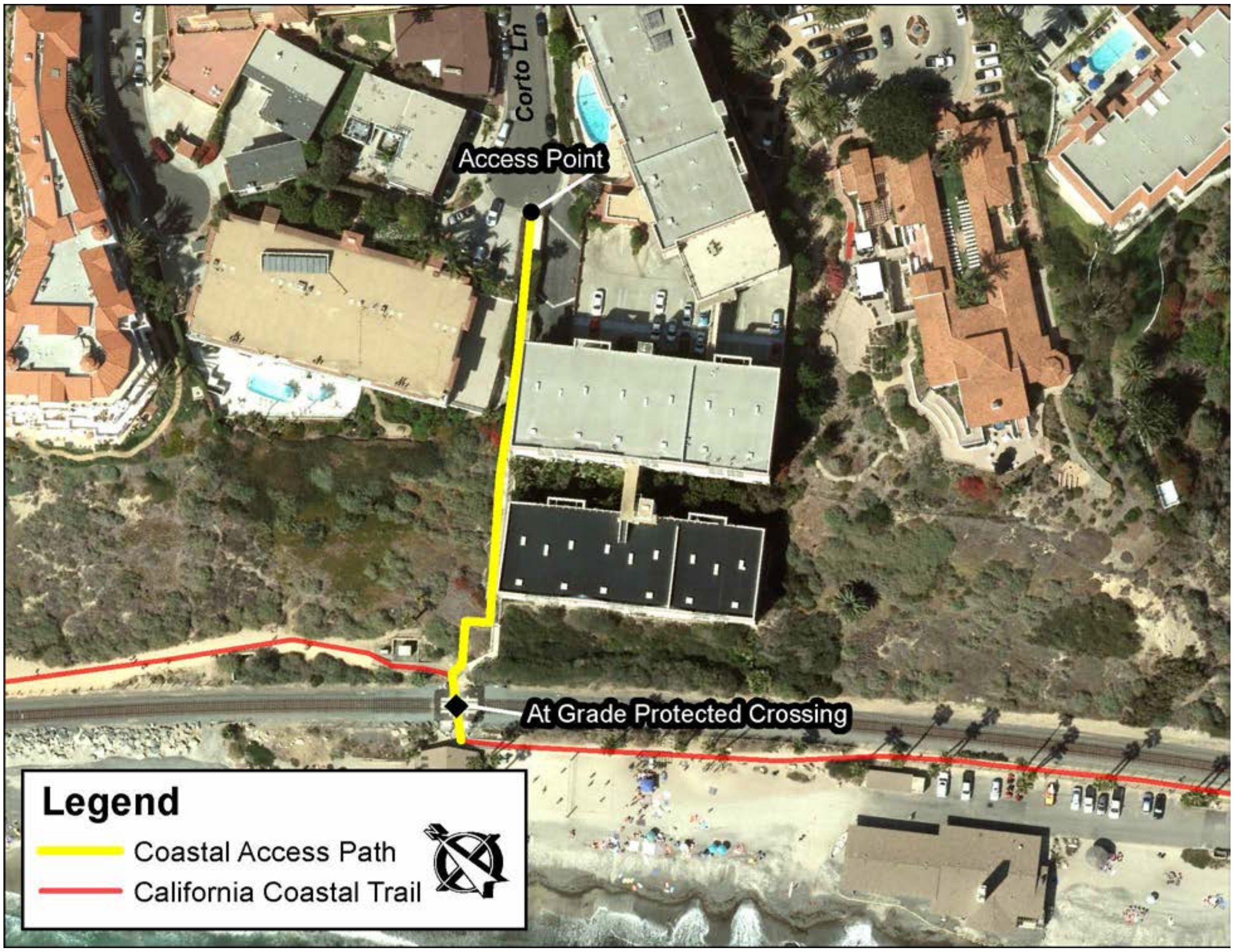


Figure 41: Public Access Point: Corto Lane

Public Access Point: Municipal Pier

The Municipal Pier access can be reached by a number of routes through San Clemente. The most direct route is provided by Avenida Del Mar and Avenida Victoria, turning west from El Camino Real. The configuration of Avenida Del Mar and Avenida Victoria form the "bowl" of the pier area and are the main components of the roadway network in the vicinity. Avenida Granada, Avenida Rosa, and Avenida Algodon also provide convenient access to the Pier Bowl by connecting with Avenida Del Mar and Avenida Victoria west of El Camino Real. Access to the Pier Bowl is also available by bus, established bicycle routes, and the beach trail.

The Municipal Pier access is located at the base of the Municipal Pier adjacent to commercial shops, train and bus stops, a park, the beach and the Marine Safety Headquarters. The beach is very popular for surfing, body boarding, swimming, and sunbathing. The pier offers fishing, scenic walks and a small concession and bait-and-tackle shop at the end. The Fisherman's restaurant, bar, and beach concession stand are located at the base of the Pier. The Pier Bowl area is also known for its special community events--such as the Fourth of July fireworks show, Chowder Cook-Off, and Ocean Festival. Due to the diversity of attractions in the Pier Bowl, the Municipal Pier access receives the highest use of any access in the City.

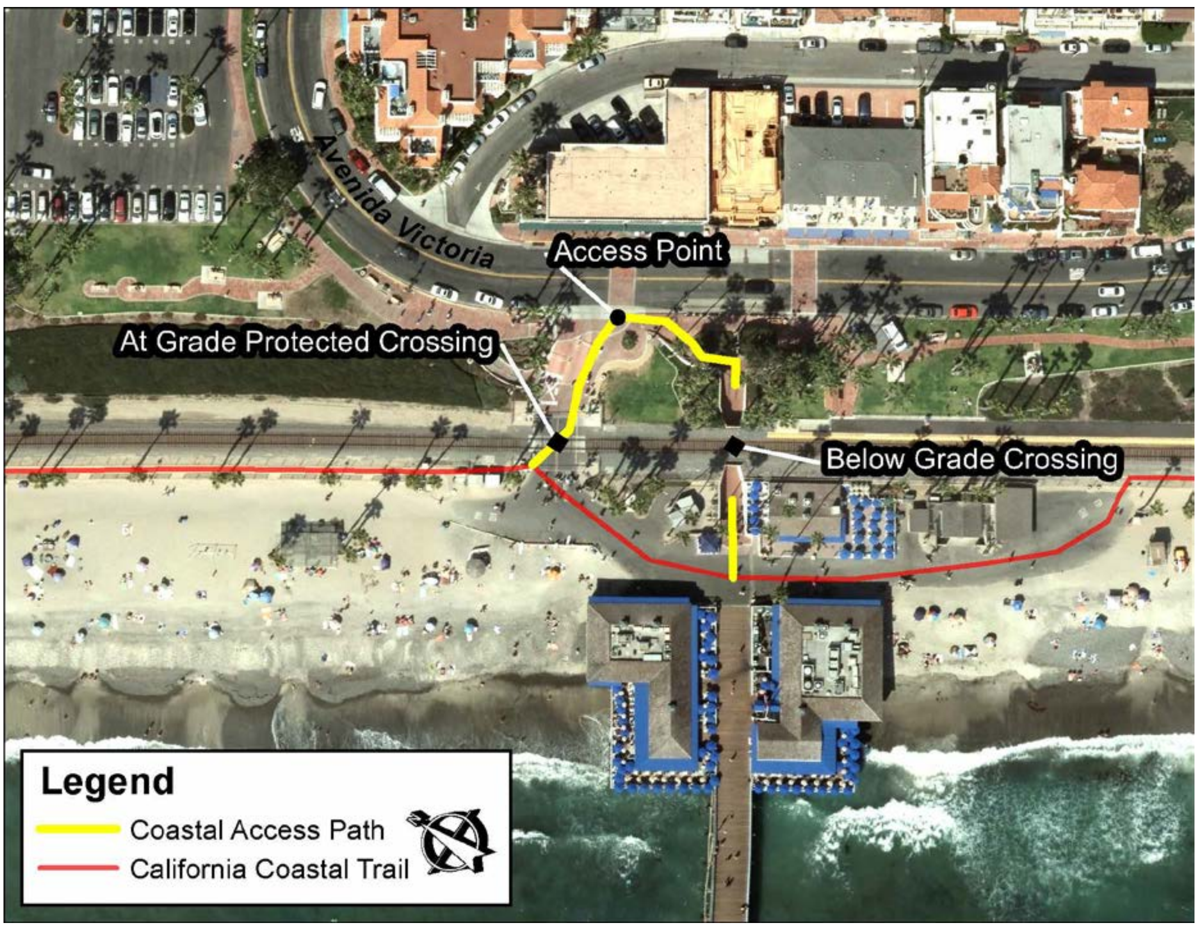


Figure 42: Public Access Point : Municipal Pier

Coastal Access Point 10: Trafalgar Canyon

Access to the beach begins off of South Ola Vista along a drainage easement that follows the bottom of the Trafalgar Canyon down to the beach. At the end of the canyon the beach is accessed under a railroad trestle. This is not an official City maintained or City owned access way to the beach and this access way traverses private property.

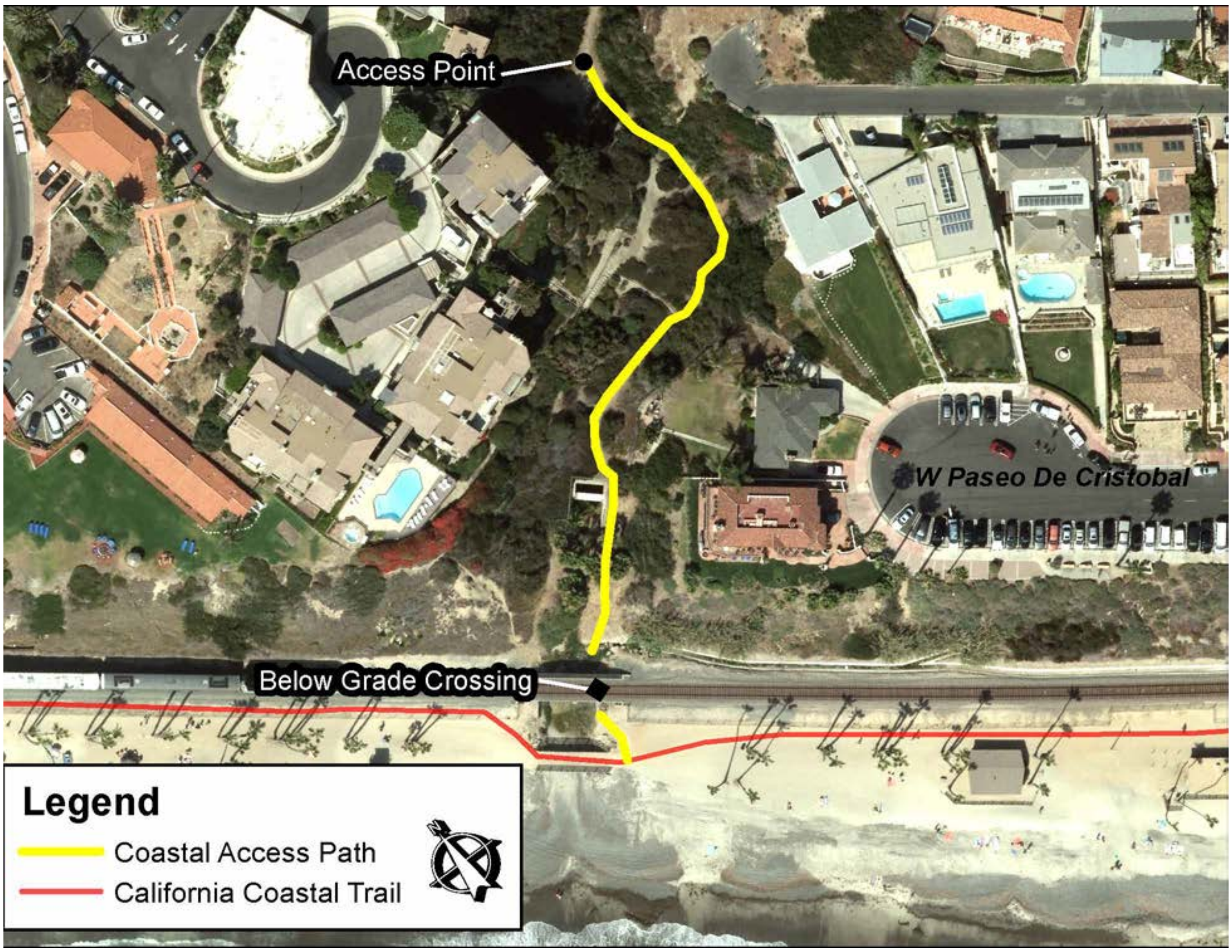


Figure 43: Access Point: Trafalgar Canyon

Public Access Point: T-Street

The T-Street access is located at the end of West Paseo de Cristobal, which can be reached by the Avenida Presidio exit from the 1-5 Freeway, using either Esplanade or West Paseo de Cristobal from El Camino Real. The access point is a pedestrian railroad overpass from an on-street metered parking area which accommodates approximately 107 cars with 78 metered spaces. The concrete overpass was constructed in 1981 for safe pedestrian access over the railroad tracks. Public facilities on the beach at T-Street include restrooms, showers, fire pits, snack shop, shade structures, and picnic tables. There is a bluff top walk with benches overlooking the coast.

Figure 44: Public Access Point: T-Street

Private Access Point: La Boca del Canon

This private access is reached by either Avenida Presidio or El Camino Real exits from the I-5 Freeway. It is located on La Boca del Canon, a private residential street with a vehicle gate which connects to La Rambla. Public access to the beach is available nearby at either "South T-Street" or Lost Winds, both protected pedestrian railroad crossings. Parking in the gated private community is limited to on-street spaces for residents and guests of La Boca del Canon; however, public parking is available on surrounding public streets. There are no public facilities on the beach at this location. This access point is located at the point where the City beach ends and the State beach begins.

Figure 45: Private Access Point: La Boca del Canon

Public Access Point: Lost Winds

The Lost Winds beach access is located 435 feet south of Leslie Park, off the streets Calle de Los Alamos and Calle Lasuen. Originally named after the street "Lasuen," mispronunciation over the years has transformed the name of this beach to "Lost Winds." The Lost Winds access is a ten-foot-wide public easement between two private residences consisting of a dirt path that leads from the street down a steep bluff slope. The upper portion of the path consists of decorative interlocking paver, then steps formed from railroad ties lead to a dirt path that slopes gradually down a small valley to the beach. Access to the beach is via a protected pedestrian at-grade railroad crossing. The beach area is improved with three volleyball courts. Parking at both Leslie Park and the beach is limited to on-street spaces. The Lost Winds access is located within a residential area, and for this reason, it is used primarily by local residents of San Clemente. Lost Winds is a popular surf break.

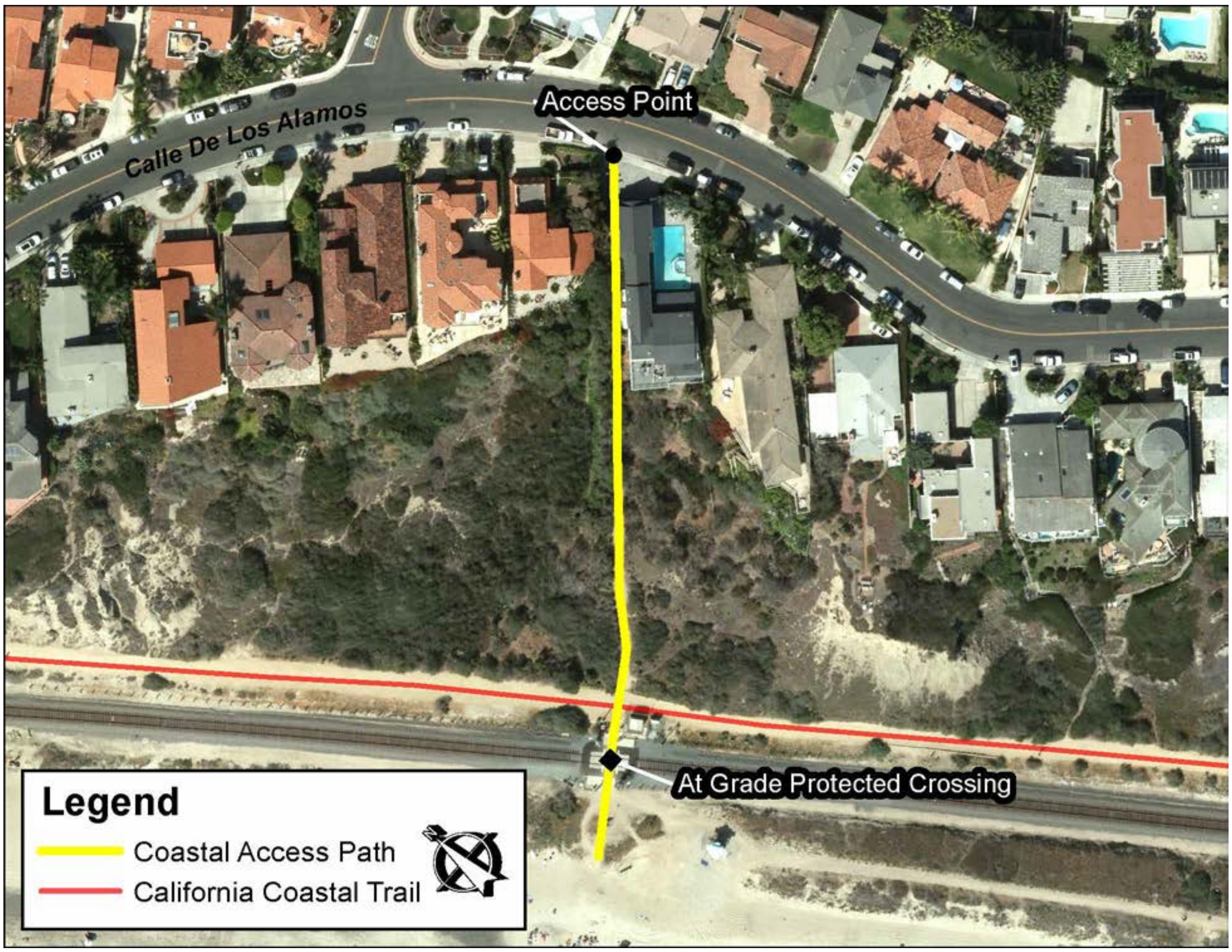


Figure 46: Public Access Point: Lost Winds

Public Access Point: Riviera

The Riviera access is shown on Figure 47. It is located adjacent to a small canyon and concrete drainage channel the access is somewhat isolated. The only amenity provided at the beach is one fire pit. The beach is very popular among local surfers and sunbathers. Vehicular access is off South Ola Vista via Avenida de la Riviera, Calle Monte Cristo, and Avenida la Costa to Plaza a la Playa. The beach trail and beach access are located at the northern portion of the Plaza a la Playa cul-de-sac. The accessway consists of a short concrete footpath and stairway, which leads to a concrete storm drain tunnel under the railroad tracks. This access is especially beneficial in that the location of adjacent residences and the local topography result in the tunnel being the easiest route to the beach. Parking is limited to on-street spaces. There are no signs indicating the access location.

Figure 47: Public Access Point: Riviera

Public Access Point: Montalvo

This access point is located where the street Avenida Montalvo changes into Avenida Lobeiro. The portion of this access extending from the street to the canyon bottom was required as a condition to the Sea Point Villa's development. An additional easement to complete the access over private property within Montalvo Canyon was obtained by the City. The access point is taken off Avenida Montalvo, along the eastern side of the Sea Point Villa project. A stairway leads to the bottom of Montalvo Canyon, where a small bridge extends over the drainage in the canyon bottom and connects to the beach trail and under the train trestle to the beach. The access point is difficult to find and for this reason is used mainly by the residents in the area.

Figure 48: Public Access Point: Montalvo

Public Access Point: Avenida Calafia - San Clemente State Beach

The third beach access point in the Calafia/South Area is at the northwestern edge of the San Clemente State Beach. This access point is reachable via Avenida Calafia, which leads directly to the beach. Avenida Calafia is one of the most direct, and therefore easiest, vehicular routes to the shoreline from points inland. Pedestrian access is also available from Avenida Lobeiro through Calafia Park with stairs that lead down to the beach access point.

Present facilities at Calafia Beach include:

- Beach concession stand
- Restrooms
- Showers
- Picnic tables
- 208 metered parking spaces

Beach access is by way of a protected pedestrian at-grade railroad crossing and stairs that lead down to the beach. This is also the southern trailhead for the beach trail, which runs north 2.3 miles to North Beach.

Figure 49: Public Access Point: Avenida Calafia - San Clemente State Beach

Public Access Point: San Clemente State Beach

Access to the San Clemente State Beach is taken off Avenida Calafia where it intersects with a road accessing the campgrounds and beach area. San Clemente State Beach consists of 6,000 feet of ocean frontage and contains 110 acres of beach and upland area. Perpendicular sandstone cliffs, 70 feet in height, face the ocean beach. The sandstone bluffs found in this area provide an excellent example of the area's ancient submarine landscape and are often used by local colleges and high schools for geology field studies. The campground is located on top of an uplifted marine terrace at about the 100-foot elevation contour. The bluffs and terrace are interrupted by many deeply eroded canyons and arroyos.

Present facilities at San Clemente State Beach include:

- Group camp
- Campsites
- Trailer sites with connections
- Picnic sites
- Day use parking spaces
- Beach lifeguard facilities
- Park office and facilities

A path from the camp grounds and day use parking lot at the top of the bluff within the State Park provides access to the beach.

Figure 50: Public Access Point: San Clemente State Beach

Private Access Points: Avenida de Las Palmeras/Calle Ariana

The two remaining access points are located in the southern portion of the Calafia/South Area. Both accesses are privately maintained and controlled, access to the public is prohibited. Access Point 17, Avenida de Las Palmeras, (see Figure 51) is the principal beach access for the Cyprus Shores and Cove communities. There is a paved roadway leading to the beach, with a limited number of parking spaces, a clubhouse, park and picnic area. These facilities are used exclusively by residents of Cyprus Shores and Cove and their guests and are not open to the public. Beach access is provided via an underpass beneath the trestle. Public access is allowed seaward of the mean high tide line.

Calle Ariana (see Figure 52) is a foot path leading to the beach. The path forms an extension of Calle Ariana and runs along the boundary line between the Cyprus Shores and the Cotton's Point Estates Communities. There are no beach facilities at this location. This site is a private access for the exclusive use of residents and guests of the Cyprus Shores community. There is no approved licensed access at this point over the railroad tracks, which is dangerous because of the high speed of the trains at this point and the curve of the railroad tracks. Public access is allowed seaward of the mean high tide line.

Figure 51: Private Access Point: Avenida de Las Palmeras

Figure 52: Private Access Point: Calle Ariana