Revised Draft

Coastal Hazard Vulnerability Assessment, City of Oceanside

Prepared for
City of Oceanside

March 2018 – revised September 2018

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Section 1

INTRODUCTION

Future sea-level rise is expected to create a permanent rise in ocean water levels that would shift the water's edge landward. If no action is taken, higher water levels would increase erosion of the beach, cause a loss of sand, and result in a narrower beach. Additionally, the combination of higher ocean water levels and beach erosion would result in greater flooding and damage during coastal storms.

The City of Oceanside is updating its Local Coastal Program (LCP), a planning document that regulates development in the City's coastal zone and establishes a long-range vision for the community. The California Coastal Act, passed in 1976, provides for coastal jurisdictions to adopt a LCP to ensure local implementation of Coastal Act priorities. The City of Oceanside's current LCP was certified by the California Coastal Commission (CCC) in 1986. In August 2016, the City of Oceanside received a grant from the CCC to provide a comprehensive update to the LCP based on two published CCC documents: the LCP Update Guide and Sea Level Rise Policy Guidelines (Section 2.1.2). The City is currently preparing an update to its LCP, with support of the CCC, in part, to address anticipated sea-level rise and its effects on coastal erosion and flooding. Environmental Science Associates (ESA) performed this Vulnerability Assessment to address existing conditions and future vulnerability of the city of Oceanside and its social, economic, and physical coastal resources to projected sea-level rise, coastal flooding, and erosion. The findings of this assessment will enable ESA to assist the City with development of adaptation strategies to prepare for future impacts and policy language for incorporation into the City's LCP Update.

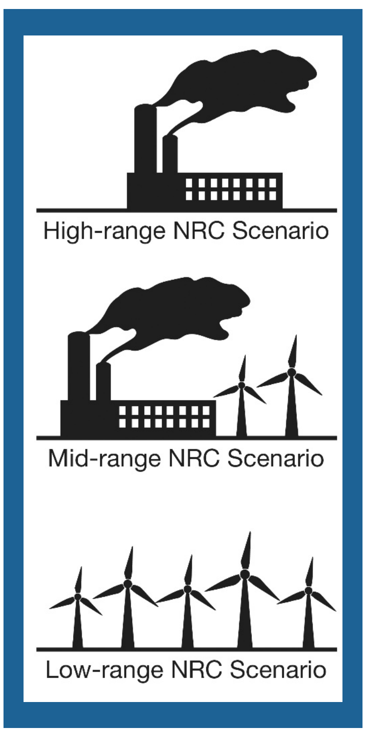
ESA's potential coastal hazard analysis and vulnerability assessment is a planning-level assessment meant to inform the development of an Adaptation Plan and related LCP policies. Utilizing available coastal hazard mapping products discussed in Section 2.1.3 and Section 4, this assessment relies on reasonable assumptions and engineering judgement to simplify the analysis where needed.

Section 2

DATA COLLECTION AND PROCESSING

ESA collected publicly available data on physical processes impacting coastal and riverine flooding, as well as data on coastal assets (i.e., valuable natural or built resources) in Oceanside. The data included in the following sections relate specifically to the vulnerability assessment. Additional data and background is included in **Appendix A** and will be used in the development of the Adaptation Plan.

2.1 Sea-Level Rise Scenarios[1]



Information on current science and state guidance on potential sea-level rise is discussed in the following sections. The planning horizons and sea-level rise scenarios selected for this study are discussed in Section 2.1.4.

2.1.1 Regional Sea-Level Rise Projections[2]

The National Research Council (NRC) produced a report on potential sea-level rise specifically for California, Oregon, and Washington in 2012. The NRC document presents different sea-level rise scenarios through 2100 for three global greenhouse gas emissions scenarios:

High-range NRC Scenario – This scenario assumes a potential population growth that peaks mid-century, high economic growth, and development of more efficient technologies. The associated energy demands would be met primarily with fossil-fuel intensive sources.

Mid-range NRC Scenario – This scenario makes the same assumptions as the high-range scenario for growth, but also assumes that energy would be derived from a balance of sources including a mix of fossil-fuel intensive sources and

[1] A sea-level rise scenario is a potential amount of sea-level rise occurring by a certain date. Typically, multiple scenarios are chosen to represent the range of possible outcomes, since the exact amount of sea-level rise is uncertain and depends on future greenhouse gas emissions.

[2] A sea-level rise projection is a scientific estimate of how much sea-level rise is expected to occur by a certain date based on varying assumptions.

renewable energy sources, such as wind farms and solar panels, thereby resulting in reduced total greenhouse gas emissions and emission rates relative to current emissions levels.

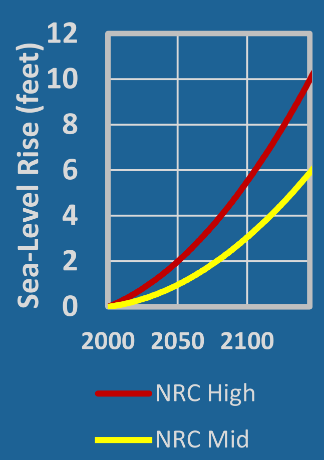
Low-range NRC Scenario – This scenario assumes a potential shift toward a lower-emission service and information economy featuring cleaner technologies, thereby resulting in significant reduction of greenhouse gas emissions relative to current emissions levels.

NRC evaluated the associated sea-level rise projections for each of the above-noted emissions scenarios (low, medium, and high). **Table 2-1** presents the results of the NRC study for Southern California. These sea-level rise projections are defined relative to the sea level measured in the year 2000.

Table 2-1. NRC Sea-Level Rise Projections

Emissions Scenario	2030	2050	2100
Low	2 in	5 in	17 in (1.4 ft)
Mid	6 in	11 in	37 in (3.1 ft)
High	12 in	24 in	66 in (5.5 ft)
SOURCE: NRC 2012			

Potential Sea-Level Rise in Oceanside to 2100 and Beyond



Additionally, the Ocean Protection Council (OPC) recently finalized the State of California Sea-Level Rise Guidance, 2018 Update (California Natural Resources Agency (CNRA) and OPC 2018) during the preparation of this Vulnerability Assessment. This Vulnerability Assessment uses the NRC (2012) report because the CNRA and OPC (2018) report was not yet finalized when this Vulnerability Assessment was performed. The CNRA and OPC (2018) study provides updated estimates of potential sea-level rise amounts based on low and high emission scenarios (**Table 2-2**). The updated science shows that the low emissions scenario is likely to cause higher sea-level rise than projected in the NRC report, but that the high emissions scenario is likely to cause lower sea-level rise than NRC projections. The study also considers a more extreme scenario resulting in rapid sea-level rise of 10 feet by 2100 due to the loss of the West Antarctic ice sheet.

Emissions Scenario	2030	2050	2100
Low	-	-	30 in (2.5 ft)
High	7 in	14 in	43 in (3.6 ft)
High + loss of West Antarctic ice sheet	13 in	34 in	122 in (10.2 ft)

Table 2-2. OPC Likely Range Sea-Level Rise Projections at

SOURCE: CNRA and OPC 2018

Recent studies indicate that emissions since 2000 have not been reduced to the level assumed in the NRC low-range emissions scenario (Rahmstorf et al. 2012; Horton et al. 2014). With little to no reduction in emissions between 2000 and 2012/2014 (depending on the timing of when the studies were published), it is unlikely that sea-level rise will be as low as the NRC low projection. This has shifted the focus of current sea-level rise studies to a reliance on the mid- and high-range emissions scenarios. For example, the OPC report does not consider low emissions scenarios for 2030, 2040, or 2050.

While the NRC report provides projections through 2100, it is important to note that sea-level rise is expected to continue for centuries beyond 2100, because the earth will require time to equilibrate[3] to the emissions that have already been released to the atmosphere. The OPC report provides projections through 2150 to acknowledge this. Although sea-level rise is typically presented as a range in the amount of sea-level rise that will occur by a certain date (e.g., 1-2 feet of sea-level rise by 2050), it can also be presented as a range of time during which a certain amount of sea-level rise is projected to occur (e.g., 1.5 feet of sea-level rise between 2040 and 2070). With that in mind, it is important to note that even if emissions are reduced to levels consistent with the mid-range scenario, sea-level rise as reflected in the high-range projections will still occur, just at a later date.

2.1.2 State Planning Guidance

The CCC produced sea-level rise policy guidance in 2015. The guidance recommends using the NRC climate change scenarios at various planning horizons to assess vulnerability and conduct adaptation planning. The guidance provides a step-by-step process for addressing sea-level rise and adaptation planning in updated LCPs (CCC 2015:18).

State planning guidance calls for considering a range of scenarios (OPC 2013; CCC 2015) in order to bracket the range of likely impacts. Scenario-based analysis promotes the understanding of impacts from a range of scenarios and identifies the amounts of climate change that would cause these impacts. Section 2.1.4 presents the scenarios considered for this vulnerability assessment.

[3] Return to equilibrium

2.1.3 CoSMoS Modeling Scenarios

The Coastal Storm Modeling System (CoSMoS) was developed by the United States Geologic Survey (USGS) with state funding for use in LCPs. The modeling effort focused on evaluating flood hazards associated with sea-level rise, as well as shoreline and bluff erosion. A total of 40 scenarios were run for three coastal storm events (100-year, 20-year, and 1-year events, or the 1%, 5% and 100% annual chance events) and nine sea-level rise amounts (0.25 to 2 meters at 0.25 meter increments and 5 meters). Model outputs include inundation, wave runup, and long-term erosion (see photo box to the right).

Inundation:

Photo by Scott Nightingale, City of Oceanside

Wave runup:

Video by Scott Nightingale, City of Oceanside

Erosion:

Photo from Kuhn and Shepard 1984

2.1.4 Oceanside Sea-Level Rise Scenarios

To assess vulnerabilities for the city of Oceanside, four sea-level rise scenarios were selected to bracket the range of potential impacts that the City can expect in the future. The scenarios were chosen based on the State guidance to use the NRC (2012) projections and the available CoSMoS model runs. The scenarios were developed with input from the City of Oceanside LCP Internal Steering Committee, which includes the following City departments: Development Services, Public Works, Fire, and Water Utilities. **Table 2-3** presents the sea-level rise scenarios used for this Vulnerability Assessment, which are based on NRC. The first date in the date range assumes that emissions track on the high-range scenario, while the later date assumes lower emissions are achieved (mid-range scenario), thereby delaying the extent of potential sea-level rise. The first date is generally consistent with the medium-high risk aversion from the updated CNRA and OPC (2018) report. The updated projections recommended by CNRA and OPC (2018) for high risk aversion (i.e., high emissions + loss of West Antarctic ice sheet scenario, see Table 2-2) could occur sooner; however, as discussed above, the CNRA and OPC (2018) report was finalized after this Vulnerability Assessment was performed and the CNRA and OPC (2018) high risk aversion scenario was therefore not assessed.

Table 2-3. Oceanside Sea-Level Rise Scenarios

Scenario	Date Range	Potential Amount of Sea-Level Rise	
		(ft)	(m)
Existing conditions	Now	0	0
Short-term	2025 – 2045	0.8	0.25
Mid-term	2040 – 2070	1.6	0.5
Long-term	2070 – 2100	3.3	1
Longer-term	2100 – 2140	5.7	1.75

SOURCE: NRC 2012, Erikson et al. 2017

2.2 Asset Inventory

Oceanside has the following built and natural assets that are currently or may potentially become vulnerable to tidal inundation, storm flooding, waves, and erosion due to sea-level rise. These assets were processed in GIS with sea-level rise related hazard layers to assess vulnerability (Section 5). The data sources for each asset class are presented in **Appendix B**.

Building Assets

Residential buildings
Commercial retail/offices
General industrial
Mixed use
Schools and religious facilities
Child care facilities
Colleges, schools, and libraries
Mobile home and RV parks
Health care facilities
Fire stations
Police stations
Lifeguard headquarters
Hotels and lodging
Emergency shelter sites

Infrastructure Assets

Highway bridges
Highways
Roads (local)
Railroads
Communications towers
Communications lines
Electrical transmission lines
Natural gas pipelines
Storm drain system
Wastewater pump stations
Wastewater treatment plant
Water mains and pipes
Water pump stations
Water treatment plant
Wastewater outfalls
Wells
Fire hydrants
River levees and floodwalls
Groins, jetties, and breakwaters
Shoreline protective devices
Sanitary sewer pipes

Hazardous Materials

Hazardous material sites
Underground chemical storage tanks

Natural Assets

Beaches
Bluffs
Wetlands
Preserves
Critical species habitats

Cultural Assets

Historic-period built resources
Native American cultural resources
Paleontological resources
Cemeteries
Archaeological resources

Public Access and Recreation Assets

Beach access points
Parks and open space
Oceanside Pier
Bicycle routes
Trails

2.3 Critical Asset Owners/Managers

The following agencies include entities that own, operate, or have regulatory authority over natural and built assets within Oceanside both within and outside the coastal zone. Main asset categories are listed for each entity, along with source descriptions and known data gaps.

2.3.1 City of Oceanside

The City of Oceanside owns and operates the following assets

- City-owned buildings
  - Fire stations
  - Police station
  - Lifeguard headquarters
  - Buildings in the Oceanside Harbor (leased to others)
- Water infrastructure
  - Robert A. Weese Filtration Plant
  - Mission Basin Groundwater Purification Facility
  - Distribution pipelines
  - Pump stations
  - Wells
- Wastewater infrastructure
  - San Luis Rey Water Reclamation Facility
  - La Salina Wastewater Treatment Plant
  - Sewer pipelines
  - Pump stations
  - Outfalls
- Stormwater infrastructure
  - Storm drains
  - Outfalls
- Local roads
- Fire hydrants

- Coastal structures (e.g., Oceanside Pier)
- Shoreline protective devices (e.g., riprap, seawalls)
- Beach access points
- Parks and open space
- Trails
- Bicycle routes

2.3.2 Communications Companies

Communications lines and towers (such as cellular equipment and broadband) are owned and managed by communication companies, such as AT&T. Data for these assets has not been collected for this assessment, but could be included in future studies.

2.3.3 San Diego Gas & Electric

ESA obtained available data from CA Energy Commission (CEC) for electrical transmission lines and natural gas pipelines. The CEC does not maintain data for local distribution gas pipelines and electrical lines. SDG&E operates natural gas and electricity transmission lines and associated facilities in Oceanside. Data from SDG&E could be included in future studies.

2.3.4 CalTrans

CalTrans manages the I-5, CA-76, and CA-78 transportation corridors in the city of Oceanside. Data was downloaded from the CalTrans online data portal, which identifies these corridors and associated bridges.

2.3.5 North County Transit District

The railroad that runs parallel to the coast is owned and operated by the NCTD.

2.3.6 U.S. Army Corps of Engineers

While the City owns the land around the San Luis Rey River, the river is considered a USACE flood control channel and USACE leads the flood management of the river.

2.3.7 California Department of Fish and Wildlife

The majority of Buena Vista lagoon is owned and managed by CA Fish and Wildlife, with the remaining portions of the lagoon owned by other public agencies and private parties.

2.3.8 US Fish and Wildlife Service

USFWS has regulatory authority over the following habitats present in the Oceanside: tidewater goby, Southwestern willow flycatcher, Least Bell's vireo, and Coastal California gnatcatcher. Habitat data was obtained from the USFWS Environmental Conservation Online System.

2.3.9 Oceanside Unified School District, Vista Unified, Carlsbad Unified, and Bonsall Elementary

Schools in Oceanside are owned and operated by four school districts: Oceanside Unified School District, Vista Unified, Carlsbad Unified, and Bonsall Elementary. Data on school properties was obtained from the City and County parcel data.

Section 3

HISTORIC EXTREME FLOOD EVENTS AND EXISTING CONDITIONS

Oceanside is currently vulnerable to tidal inundation, storm flooding, wave impact, and erosion. In the past, extreme riverine and coastal flood events have caused significant damage. This section describes the historic, extreme flood events that occurred in 1916, 1969, 1978, 1980, 1991, 1993, and 1995, as well as more recent flooding, and provides a discussion of associated damages. Historic flooding events were characterized based on news and technical reports. In the future, these existing vulnerabilities will potentially increase in intensity and frequency due to sea-level rise and climate change.

3.1 San Luis Rey River Flood of 1916

In January 1916, two significant back-to-back rain events in San Diego county caused extensive flooding and damage along the San Luis Rey River. Heavy rainfall began January 17, following several days of light rain, which had already saturated the land, priming the region for high stormwater run-off. Rain gauges within the San Luis Rey River basin recorded daily precipitation as high as 6.37 inches on January 17, 1916. The station at Oceanside recorded 1.80, 1.23, and 1.20 inches of precipitation on January 17-19, respectively (McGlashan and Ebert 1918).

The January 1916 storms caused 4 deaths and $190 million (2018 dollars) in damage. Every bridge in Oceanside was damaged or destroyed.

On January 27th, a second storm brought more rainfall to the region. The Oceanside precipitation gauge recorded 2.02 and 1.60 inches on January 26th and January 27th, respectively. The highest recorded precipitation within the San Luis Rey River watershed, which extends beyond the city boundary, was 7.73 inches for the January 26-27th storm (McGlashan and Ebert 1918).

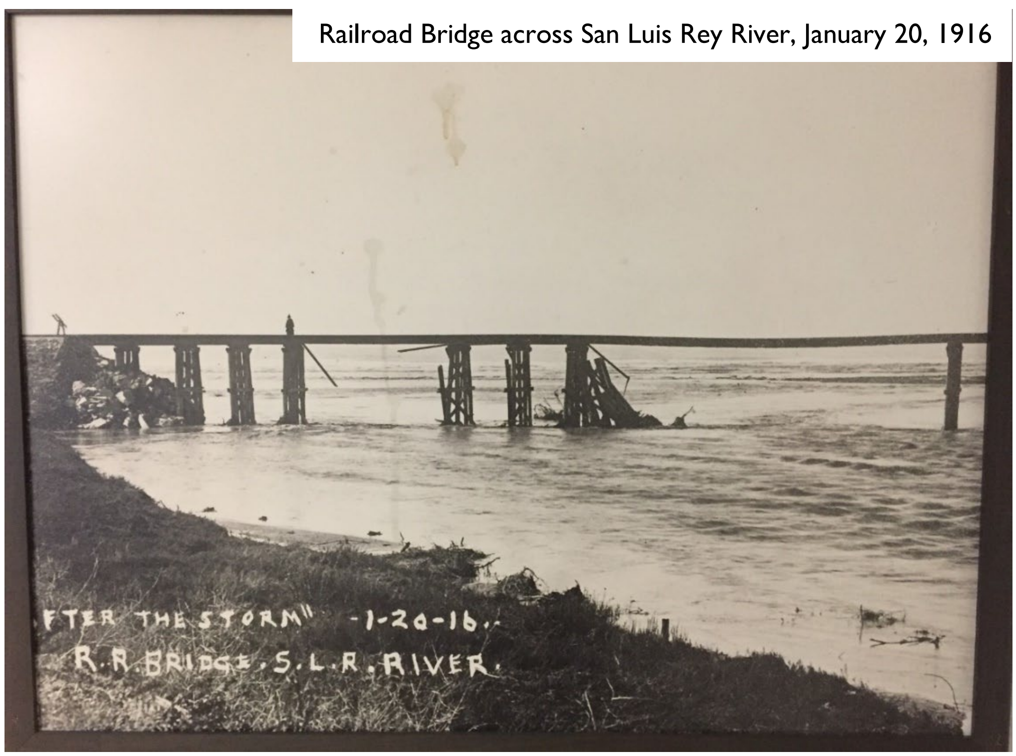
Both storms resulted in extensive flooding along the San Luis Rey River; records from 1916 indicate that more than 1,000 acres in the San Luis Rey Valley were inundated. The discharge of the San Luis Rey River at Oceanside was estimated at 40,000 cubic feet per second (cfs) for the January 17th flood, and 95,000 cfs on January 27th. The maximum discharge recorded at Oceanside for the three years preceding the January 2016 storm events (1912-1915) was approximately 7,000 cfs. The flooding damaged or destroyed all of the bridges in Oceanside and downtown Oceanside was rendered accessible only by boat for two weeks after the floods (USACE 1981, **Figure 3-1**). The flooding resulted in the deaths of four people, and total damage in the San Diego region was estimated at $8 million in 1916 dollars (NWS 2017) or roughly $190 million in 2018 dollars (US Department of Labor 2018).

3.2 Tropical Cyclone of 1939

From September 15-25, 1939, a tropical cyclone caused significant damage across Southern California; 45 deaths were attributable to fluvial flooding and an additional 48 people were killed at sea (NWS 2017). In Oceanside, 25-foot waves were recorded along the coast (Kuhn and Shepard 1984). In addition to coastal flooding, the storm caused flooding along sections of the San Luis Rey River Valley (Lawrence pers. comm. 2018).

Santa Margarita Railroad Bridge, North Oceanside

Railroad Bridge across San Luis Rey River, January 20, 1916



Source: Price 1988, San Diego History Center (top) and the City of Oceanside (bottom)

Figure 3-1. Photo of Damage on Santa Rita Railroad Bridge (top) and San Luis Rey Railroad Bridge (bottom) after January 1916 Storms

3.3 Riverine Flooding and Coastal Storm of 1940/1941

Over 7 inches of rain fell in the Oceanside area from an unusually large storm that originated in the Aleutian Islands with 20-foot accompanying waves. The combination of the heavy rain and high surf (up to 20-foot waves) caused considerable damage to the Oceanside area, including destruction of beach and bluff-top properties (Kuhn and Shepard 1984, **Figure 3-2**).

Source: D.L. Inman 1941, from Kuhn and Shepard 1984

Figure 3-2. Photo of Damage on Oceanside Coast Following December 1940/1941 storm

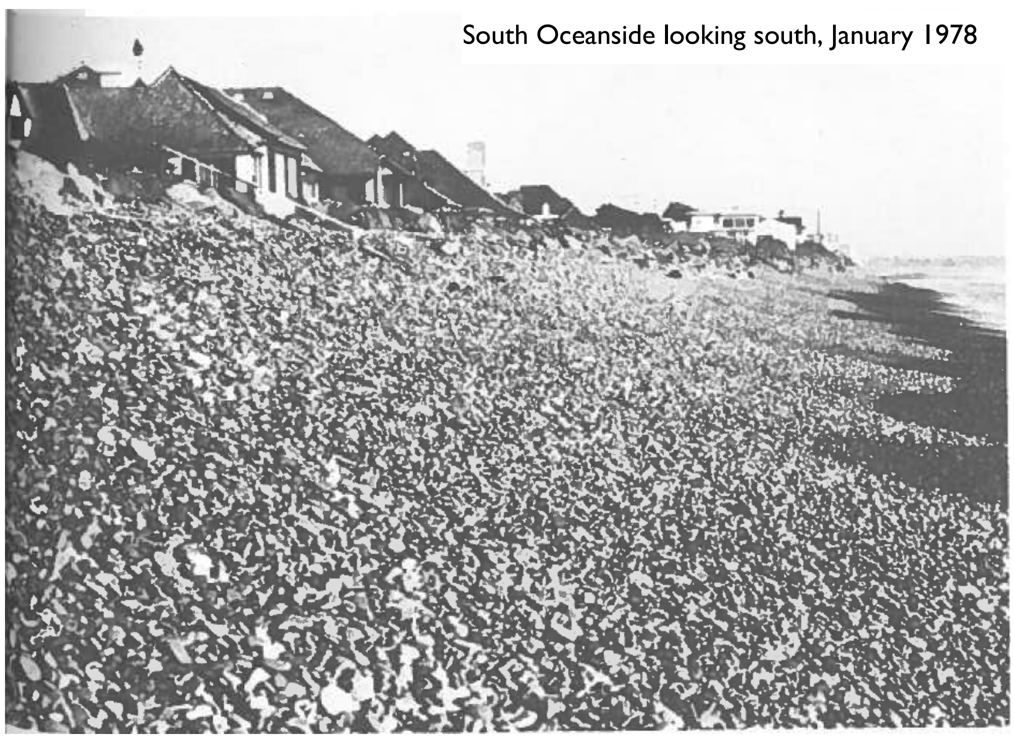
3.4 San Luis Rey River Flood of 1969

Heavy precipitation fell in San Diego over three distinct storm events between January 18 and February 25, 1969. The San Luis Rey River precipitation station at Oceanside registered a combined 5.11 inches of rain between January 18-22 and January 24-27 and 6.42 inches from February 22-25 (Reid 1975). The storm caused $200,000 in flood damage in 1969 dollars (USACE 1981) or roughly $1.4 million in 2018 dollars (US Department of Labor 2018).

3.5 Riverine Flooding and Coastal Storm of 1978

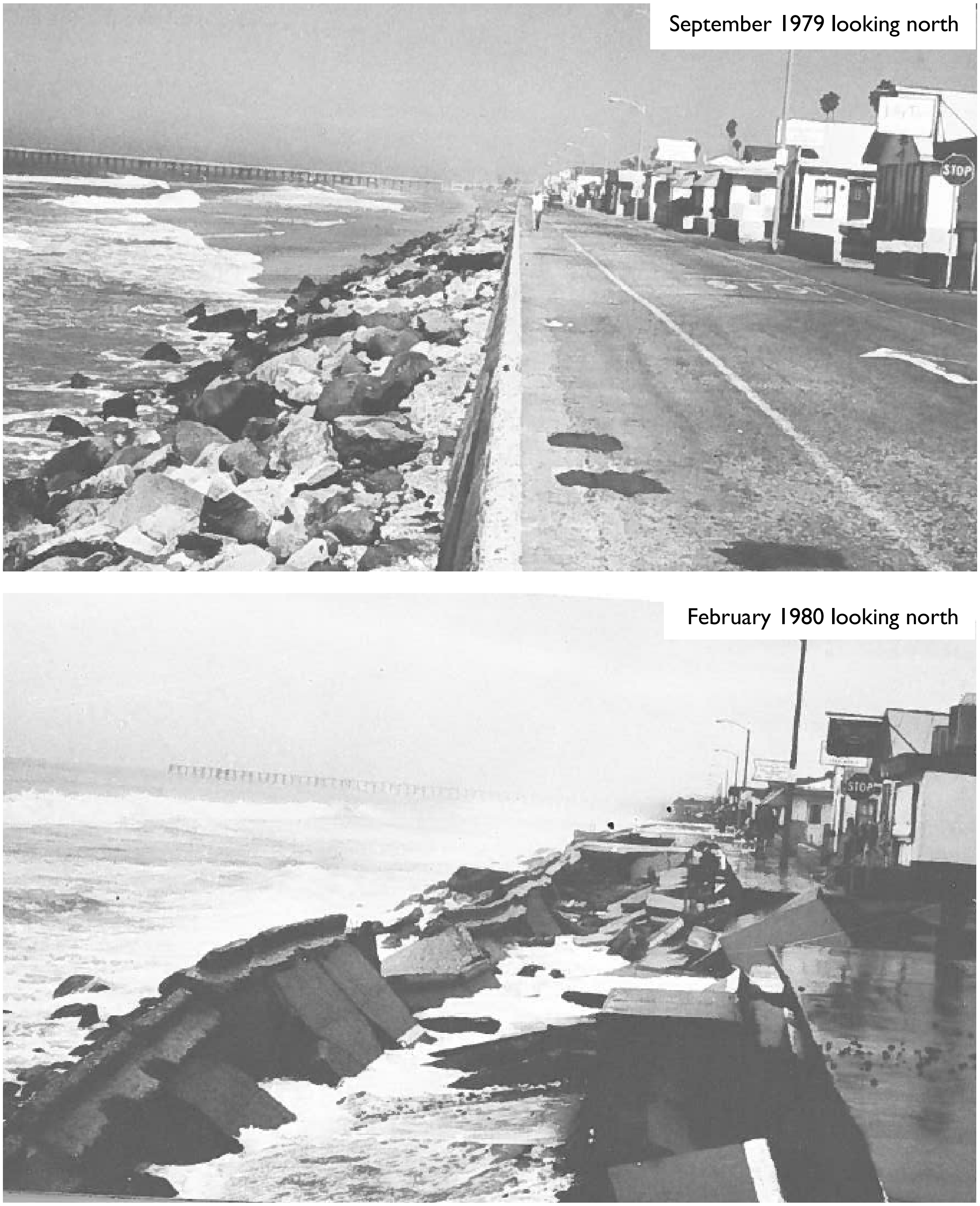
Cobbles were "thrown like artillery" at the homes along the Strand during the January 1978 coastal storm.

In January and February 1978, heavy rainfall combined with a coastal storm event resulted in substantial damage. Rainfall in the San Luis Rey River basin resulted in a peak discharge of 9,300 cfs at Oceanside. The coastal storm surge and waves stripped beach sand and cobble from the Oceanside shore, and moved it farther inland in such a fashion that residents described the cobbles as "thrown like artillery" against properties along the Strand (Kuhn and Shepard 1984). Though the wave height during the 1978 storm rarely exceeded 6 feet, cobbles moved 18 to 20 feet landward and caused broken windows and collapsed roofs (**Figures 3-3 and 3-4**). Approximately 300,000 cubic yards of sand were stripped from Oceanside beaches, and the storm caused extensive damage of the Oceanside Pier and seawalls. The storm caused approximately $3 million worth of damage in 1978 dollars ($9.5 million in 2018 dollars; USACE 1981 and US Department of Labor 2018). This total includes damages incurred from wave damage, riverine flooding, breakwater and jetty damage, and damages incurred to private and public property (USACE 1978 and 1981).



Source: Kuhn and Shepard 1984

Figure 3-3. Photo of Cobble High Up on the Beach Face after the January 1978 Storm



Source: Kuhn and Shepard 1984

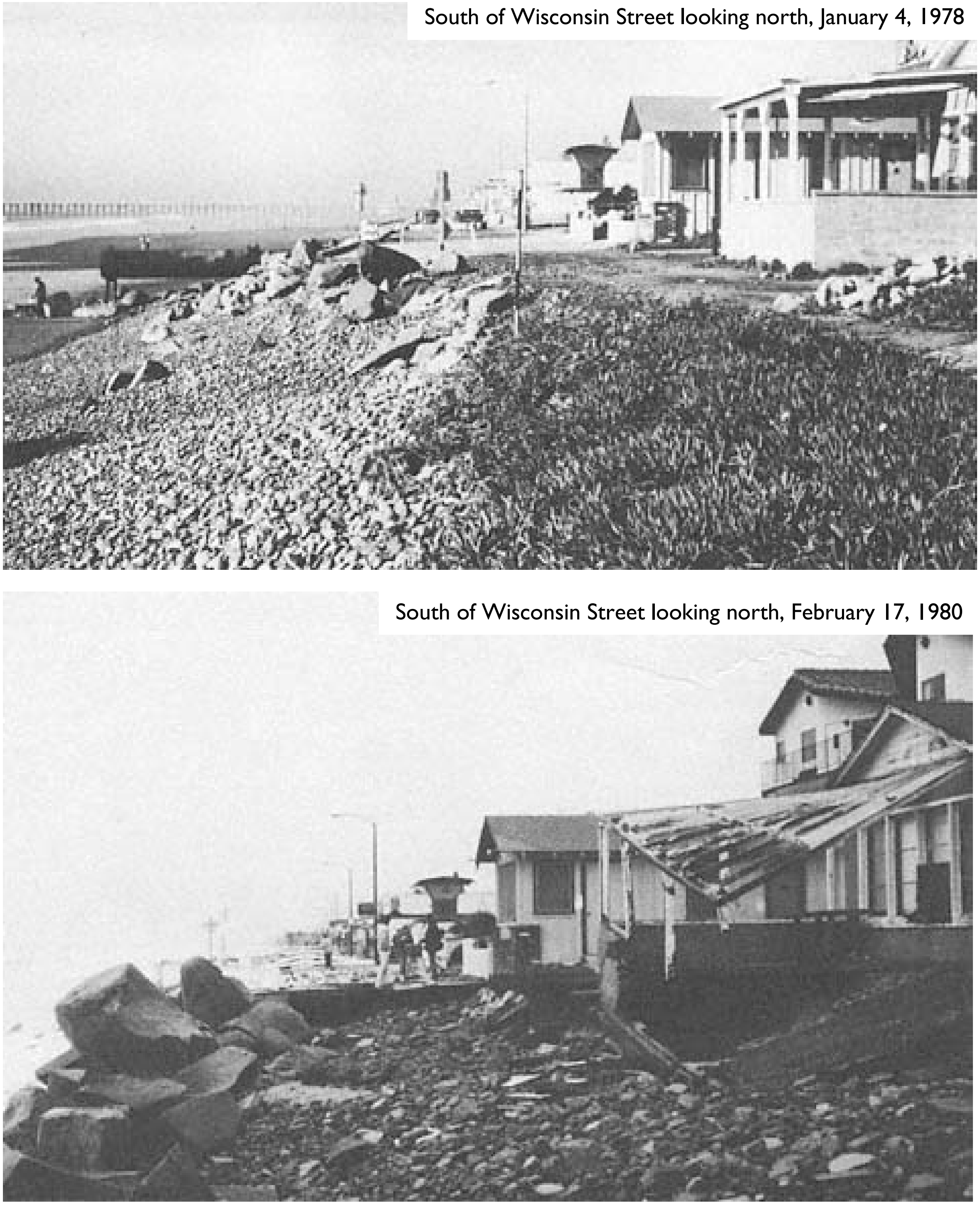
Figure 3-4. Before and After Photos Showing Damage of the Strand after the February 1980 Storm

3.6 Riverine Flooding and Coastal Storm of 1980

A series of six storm events in February 1980 caused significant flooding throughout San Diego County. Stream gauges at the San Luis Rey River at Oceanside registered a peak discharge of 25,000 cfs. The flood destroyed the Murray Road and Douglas Drive Bridge, flooded the Oceanside Airport (**Figure 3-5**), and caused extensive damage to an industrial park complex two miles upstream of I-5 when a levee broke. The 1980 storm also brought high winds and waves that reduced the Oceanside sandy beaches to cobble and caused damage to the Strand, homes, and motels (**Figure 3-6**). Damage of $2.23 million in 1980 dollars ($7.3 million in 2018 dollars) was attributed to riverine flooding and coastal damage (Chin et al. 1991).

Source: Oceanside Airport Association

Figure 3-5. Flooding of Oceanside Airport Following 1980 Storm



Source: Kuhn and Shepard 1984

Figure 3-6. Before and After Photos Showing Damage of the Cottages after the February 1980 Storm

3.7 Coastal and San Luis Rey River Flood of 1983

High surf and tides, accompanied with heavy rainfall, caused extensive damage to the Oceanside area. The San Luis Rey River suffered severe flooding, especially around the airport. Along the coastline, the high tides and surf caused extensive damage to the breakwater, pier, beach facilities, and private residences. Just south of Oceanside, the beach cliff eroded as much as 10 feet along the Carlsbad coast (Kuhn and Shepard 1984, **Figure 3-7**). Total damage to Oceanside was estimated at nearly $9 million (Lawrence pers. comm. 2018).

April 1981, View from Palomar Airport Road looking South.

February 1983, View from Palomar Airport Road looking South after storm.

Source: Kuhn and Shepard 1984

Figure 3-7. Before and After Photos Showing Coastal Beach Cliff Erosion Following 1983 Storm

3.8 San Luis Rey and Loma Alta Creek Flood of 1991

Heavy and sustained rain in January, 1991 caused damage in the San Luis Rey River and Loma Alta Creek drainages. The Douglas Drive bridge over the San Luis Rey River sustained significant scouring and debris issues due to the high river flows (Lawrence pers. comm. 2018).

3.9 Riverine Flood of 1993

Heavy and sustained rainfall throughout the month of January resulted in 20-40 inches of rain in Southern California (Bowers 1993), and caused extensive flooding in both the San Luis Rey and Santa Margarita River Basins. The USGS recorded a peak discharge of 14,000 cfs on the San Luis Rey River at Pala, CA, upstream of I-15 (Bowers 1993). The storms caused over $10 million in damage in Oceanside. Nearby Camp Pendleton suffered over $250 million in damage when the rain-swollen Santa Margarita river jumped its banks and flooded the southern section of the base. San Diego County was declared as a disaster area (NWS 2017). Extensive damage occurred along the San Luis Rey River and along the Loma Alta and Buena Vista Creeks. Two deaths were directly attributable to the storms when a vehicle drove off a damaged section of roadway and into the San Luis Rey River (Lawrence pers. comm. 2018).

3.10 Riverine Flood of 1995

In January 1995, a series of storms originating in the Pacific Ocean resulted in a three-week long period of prolonged rainfall in Southern California. Rainfall totaling over 4 inches fell in a several-hour period causing flash flooding in the area adjacent to Oceanside Boulevard and Loma Alta Creek. Areas adjacent to Garrison Creek and Buccaneer Beach were also damaged by floodwaters and rain. FEMA issued two Disaster Declarations in the region due to the severe storms, flooding, landslides, and mud flows (DR-1044 and DR-1046). Significant rainfall in March of the same year further damaged the Loma Alta Creek area.

3.11 Riverine Flooding and Coastal Storm of 1998

In February 1998, a series of storms, due in part to strong El Niño-Southern Oscillation (ENSO) conditions in the Pacific Ocean, caused substantial coastal and riverine flooding in Oceanside. The storms resulted in significant water and debris flow down the San Luis Rey River and into the Harbor, and required both a contractor and the Oceanside Harbor Maintenance division workboat to clear debris along the coast and Harbor. Two hundred people were evacuated from 3 mobile home parks within the City (County of San Diego 2007). The storm resulted in a Presidential Disaster Declaration.

3.12 Existing Conditions

Because Oceanside has a history of flooding, adaptation strategies have already been implemented to reduce the city's vulnerability to flooding. Section 3.12.1 describes recent flooding events, while Sections 3.12.2 and 3.12.3 describe the current beach nourishment operations and shoreline protections that are used to help reduce flooding and erosion.

3.12.1 Recent Flooding

Though the flood of 1916 remains the most destructive in Oceanside history, the city has experienced a number of smaller coastal flooding events in recent years. The Strand is frequently inundated and subject to wave runup and damage during coastal storms or high-tide events due to its proximity to the coast and low elevation. **Figure 3-8** below shows the aftermath of a King Tide (the highest high tides) in June 2017.

In December 2010, San Diego County experienced a week-long sub-tropical rainstorm that resulted in extensive flooding in Oceanside. The storm left approximately 1,000 residential homes without power (Robbins and Davis, 2010) and temporarily suspended the Coaster and Amtrak rail service between Oceanside and San Diego due to rain-damaged tracks and soil erosion (Forgione 2010). The storm caused significant debris flow into the Harbor and coast line and necessitated the rental of heavy equipment to remove the coastal debris. The 2010 storm received a Presidential Major Disaster declaration. **Figure 3-9** shows the inundation at the Oceanside/Carlsbad border on Coast Highway.

Source: Johnny Lara, City of Oceanside

Figure 3-8. Photos Showing the Cobbles Thrown on the Strand after King Tides in June 2017

Source: Scott Nightingale, City of Oceanside

Figure 3-9. Photo Showing Flooding of Coast Highway in December 2010

Beach nourishment involves placing additional sand on a beach to raise the shoreline profile, which, in turn, extends the beach farther seaward, creating a wider beach.

3.12.2 Beach Nourishment

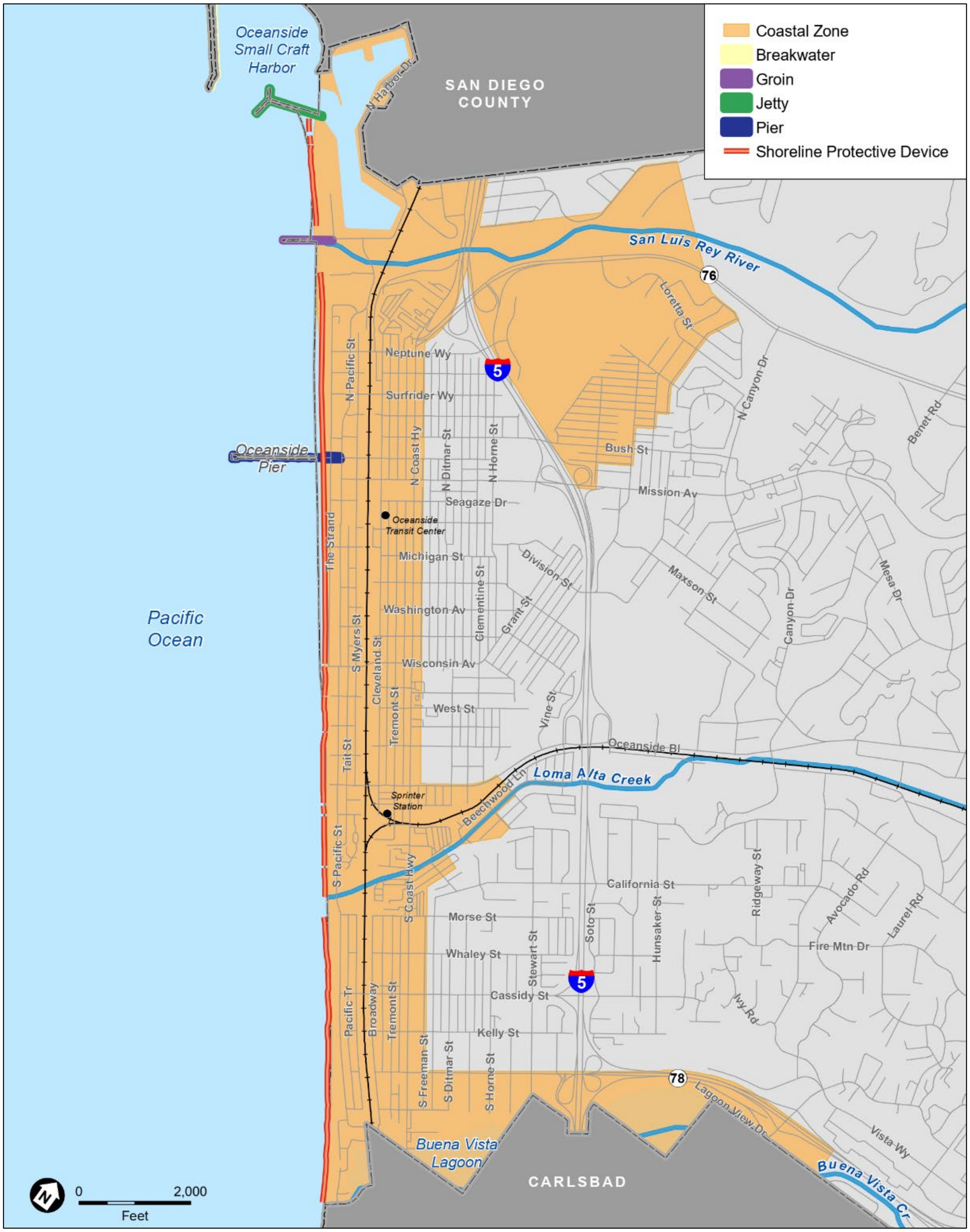
Beach nourishment can help reduce flooding and counteract coastal erosion and is a strategy that Oceanside currently uses to reduce vulnerability. Sand bypassing at the Harbor, which involves removing sand from within the Harbor and placing it on the downshore beach, has occurred either annually or biennially since construction of the Harbor began in 1961. The San Diego Association of Governments (SANDAG) has led the Regional Beach Sand Project (RBSP) with two placements in 2001 and 2012, both of which involved sand placement on the beach in Oceanside. Additionally, opportunistic sand placements occurred in the 1970s and 1980s when sand became available through other projects beyond routine Harbor dredging. Additional data and background information on beach nourishment in Oceanside is provided in **Appendix A**.

3.12.3 Shoreline Protection

Shoreline protection through seawalls or other armoring also helps reduce flooding and erosion. Much of the Oceanside shoreline already relies on shoreline protection to reduce these vulnerabilities.

An inventory of shoreline protective devices was developed in 2005 by NOAA for the entire California coastline. **Figure 3-10** shows the location of shoreline protective devices in Oceanside. The database does not detail the specific type of armoring, however conversation with City officials indicate that seawalls are the primary shoreline protective device from the northern city limits south to Tyson Street Park, and rip rap is the primary shoreline protective device from Tyson Street Park to the southern City limits (Cunningham 2018).

A jetty was constructed in the early 1940s in front of the Camp Pendleton Boat Basin. In the early 1960s, the breakwater was extended to protect the newly constructed Oceanside Harbor. In addition to the Harbor jetty, the Oceanside coastline also contains the San Luis River Groin and Long North Oceanside breakwater. Additional information on shoreline protection is provided in **Appendix A.**



Source: City of Oceanside, SanGIS

Figure 3-10. Shoreline Protection in Oceanside

Section 4

POTENTIAL FUTURE TIDAL INUNDATION, STORM FLOODING, WAVES, AND EROSION

A small storm today may cause limited damage, but with higher sea levels in the future, the same event could potentially have a much larger impact.

Future sea-level rise is expected to create a permanent rise in ocean water levels that would shift the water's edge landward. Higher water levels would increase erosion of the beach, cause a loss of sand, and result in a narrower beach, if no action is taken. Additionally, the combination of higher ocean water levels and beach erosion would mean that coastal storms will potentially cause greater flooding and damage, because reduced beach width is less effective at reducing wave energy, and waves positioned at a higher elevation allow for a deeper reach landward. For example, a small storm event under today's sea levels may not cause much damage, but with higher sea levels, the same event could potentially have a much larger impact. This section identifies five future hazard zones that constitute potential tidal inundation, storm flooding, and wave and erosion impacts associated with projected sea-level rise, the underlying data sets and assumptions associated with coastal and riverine processes for each zone, and methods used to map each zone.

4.1 Potential Future Hazard Zones

The first step in understanding Oceanside's vulnerabilities to sea-level rise is identifying potential hazard areas using available regional tools. Existing and potential future coastal tidal inundation, coastal and riverine storm flooding, and coastal waves and erosion were mapped based on the results from the USGS's CoSMoS model with some refinements made by ESA for the creek and river flooding zones.

Five potential hazard zones were mapped as part of this analysis (see **Figure 4-1** for illustrative representations of the potential coastal hazard zones presented in this report):

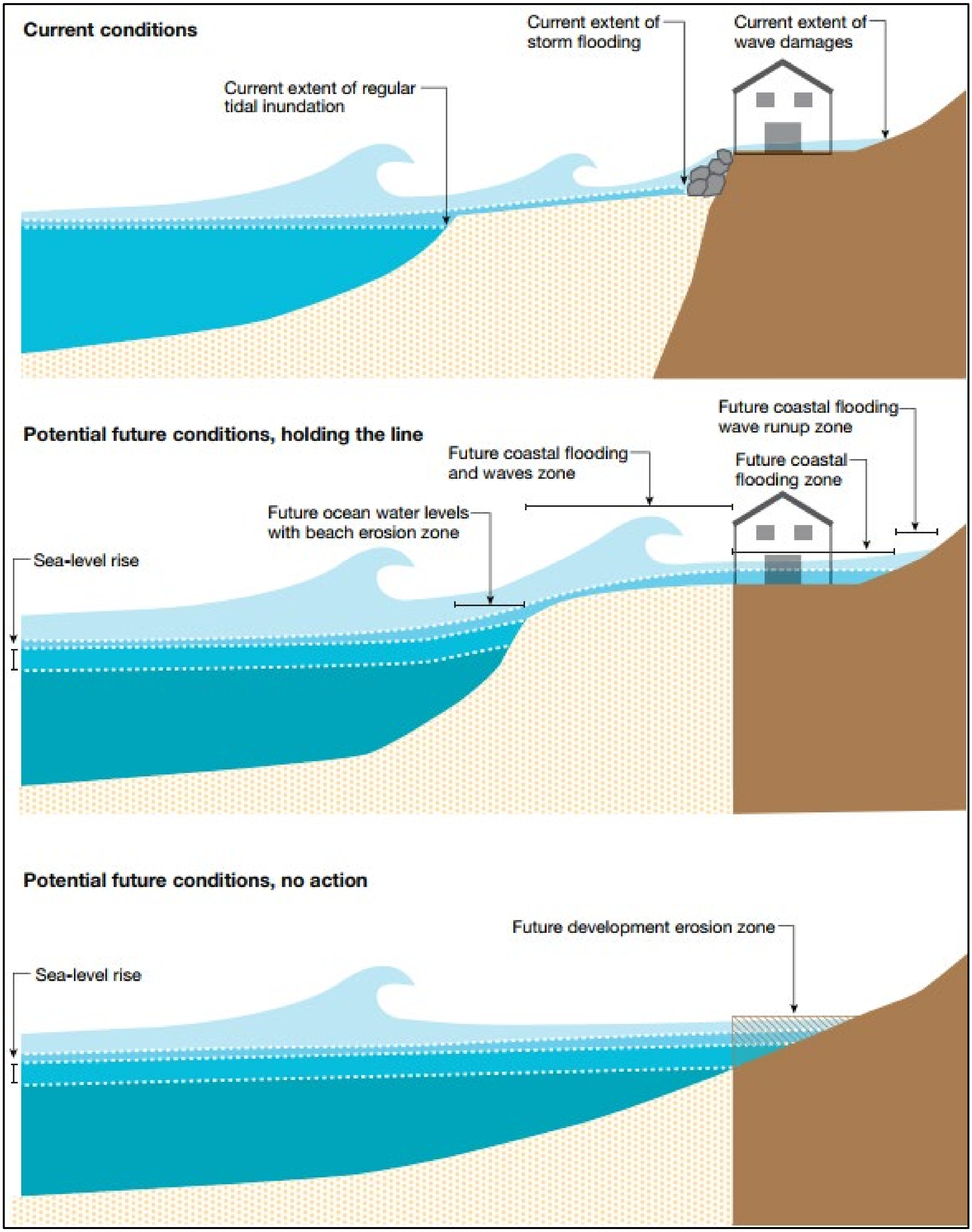
Potential future conditions, assuming repair and replacement of damaged structures (defined in CoSMoS as "holding the line") as depicted in the middle panel of Figure 4-1:

1. **Potential ocean water levels with beach erosion hazard zone:** areas where the land and structures could erode and tidal inundation could be a daily event.
2. **Potential coastal flooding and waves hazard zone:** areas that could flood during a 1% annual chance coastal storm event and experience wave impacts.
3. **Potential coastal and riverine flooding hazard zone:** areas that could flood during a 1% annual chance coastal storm or 1% annual chance riverine flood event. *Note – riverine flooding hazard zone is not illustrated in Figure 4-1.*
4. **Potential coastal flooding wave runup hazard zone:** areas that could flood due to ocean wave runup beyond inundated areas during a 1% annual chance coastal storm event.

Potential future conditions, assuming no management actions are taken to repair and replace damaged structures (defined in CoSMoS as "letting it go") as depicted in the bottom panel of Figure 4-1:

5. **Potential development erosion hazard zone:** areas that could erode if no management actions are taken. This is included to depict a potential "worst-case" scenario to have a better understanding of what the impacts could be if no action were taken, even though no action is unlikely.

The following sections describe how each flood hazard zone was developed. Section 4.1 presents the available data sources and underlying assumptions that were used to understand the different processes in the coastal zone (e.g. erosion, flooding). Section 4.2 then discusses how the different data sources were combined to develop the potential future hazard zones. Maps of the potential future hazard zones for each sea-level rise scenario are presented at the end of this section.



Source: ESA 2018

Figure 4-1. Conceptual Shoreline Cross-Sections Showing Oceanside Potential Hazard Zones

4.2 Coastal and Riverine Processes

The following sections present the data used to understand the different coastal and riverine processes in the coastal zone.

4.2.1 Beach and Bluff Erosion with Sea-Level Rise

Beach and bluff erosion results from the USGS CoSMoS model were used to develop the potential future ocean water levels with beach erosion hazard zone (Section 4.2.1) and the potential future development erosion hazard zone (4.2.5). The USGS modeled beach and bluff erosion for four management scenarios in CoSMoS:

- Hold the line, no beach nourishment
- Hold the line, beach nourishment
- Let it go, no beach nourishment
- Let it go, beach nourishment

The CoSMoS model does not directly account for beach nourishment. The model uses past shoreline position data to estimate the historic "background" rate of shoreline change (e.g., if a shoreline moves inland, the beach has eroded). This background rate is then included in the projections of future erosion with sea-level rise (i.e., results include background rate plus increased rate of erosion due to sea-level rise). The model is then run to simulate historic erosion, and if the model results show a shoreline position that is farther seaward than past shoreline position data, the model estimates the amount of beach nourishment (or other sand sources/sinks) that would have needed to occur for the model to match past shoreline position data. For the beach nourishment model scenarios, the model includes this estimate of past beach nourishment as part of the shoreline erosion projections. For the "no beach nourishment" model scenarios, the model does not include this adjustment.

The results of the CoSMoS modeling for Oceanside showed only minor differences between the "beach nourishment" and "no beach nourishment" scenarios. This is likely because past beach nourishment rates estimated by CoSMoS are not large enough to significantly offset the model's projection of potential shoreline erosion with sea-level rise. Since the results were similar, the no nourishment scenarios were used in this vulnerability assessment, because they represent the more conservative scenario of more erosion.

The "hold the line" scenario assumes that management actions are taken to repair and replace damaged structures, and development will be maintained. The "let it go" scenario assumes that no management actions are taken, and erosion can continue unabated. At this juncture, neither scenario reflects any policy determination on the part of the City; policies regarding how to address sea-level rise impacts will be embodied in the forthcoming Adaptation Plan.

4.2.2 Coastal Flood Levels with Sea-Level Rise

Coastal flooding results from the USGS CoSMoS model were used to develop the potential future ocean water levels with beach erosion hazard zone, the potential coastal flooding and waves hazard zone, the potential coastal and riverine flooding hazard zone, and the potential coastal flooding wave runup hazard zone. The USGS mapped coastal flood extent and flood depth for four storm scenarios:

- No flood (tidal inundation)
- 1-year coastal flood event (100% chance of occurring each year)
- 20-year coastal flood event (5% chance of occurring each year)
- 100-year coastal flood event (1% chance of occurring each year)

These four scenarios were mapped for nine sea-level rise scenarios, including present day mean sea level:

- 0 meters (present day mean sea level)
- 0.25 meters
- 0.50 meters
- 0.75 meters
- 1.0 meters
- 1.25 meters
- 1.50 meters
- 1.75 meters
- 2.0 meters
- 5.0 meters

As discussed in Section 2.1.4, four sea-level rise scenarios were selected for Oceanside (0.25, 0.50, 1.0, and 1.75 meters). These four scenarios and the present day mean sea level scenario were evaluated for the "no flood (tidal inundation)" and "1% annual chance coastal flood event" scenarios. The tidal inundation scenario was used to map areas where inundation is a daily event and to depict how daily inundation could potentially change in the future with sea-level rise. The 1% annual coastal flood event was chosen to represent an extreme, and, therefore, more conservative scenario. Additionally, FEMA flood mapping through the National Flood Insurance Program also provides coastal flooding extent and floodwater elevations for a 1% annual chance coastal storm event under current conditions, so the CoSMoS present day mean sea level scenario and current FEMA mapping can be compared for more confidence in the results. FEMA does not model or map coastal storm events under varying levels of sea-level rise, so the CoSMoS results were used for future scenarios.

4.2.3 Coastal Wave Runup with Sea-Level Rise

Coastal wave runup results from the USGS CoSMoS model were used to develop the potential coastal flooding and waves hazard zone and the potential coastal flooding wave runup hazard zone. The USGS mapped coastal wave runup for four storm scenarios:

- No flood (tidal inundation)
- 1-year coastal flood event (100% chance of occurring each year)
- 20-year coastal flood event (5% chance of occurring each year)
- 100-year coastal flood event (1% chance of occurring each year)

These four scenarios were mapped for five sea-level rise scenarios, including present day mean sea level:

These scenarios were modeled at discrete transects along the coast, and a point representing the inland extent of wave runup along each transect was mapped. ESA connected these points to form a potential wave runup zone. However, it is important to note that, in some cases, a linear interpolation between points is not accurate.

Since not all scenarios modeled for the coastal flooding (Section 4.1.2) were modeled for wave runup, an additional interpolation was done to develop a wave zone for 0.25 and 1.75 meters of sea-level rise. This was done by averaging 0 and 0.5 meters of sea-level rise to map 0.25 meters, and averaging 1.5 and 2.0 meters of sea-level rise to map 1.75 meters. Both the no flood (tidal inundation) and 1% annual chance coastal flood event scenarios were mapped, to match the coastal flooding scenarios discussed in Section 4.2.2.

4.2.4 River Flooding with Climate Change and Sea-Level Rise

Higher sea levels will likely increase riverine flooding, because higher ocean water levels will limit river drainage to the ocean and water will back up into the river or creek. Additionally, the sand berm at the mouth of the river or creek will likely increase in height as waves push sand up, which will also limit drainage and increase flooding.

River flooding results from multiple sources and analyses were used to develop the potential coastal and riverine flooding hazard zone. Flooding from river sources, especially the San Luis Rey River, has caused significant damage in Oceanside in the past (Section 3). Higher sea levels will likely exacerbate flooding in the lower portions of the San Luis Rey River, Buena Vista Lagoon, and Loma Alta Creek, because higher ocean water levels will limit river drainage to the ocean, so water will back up into the river or creek. CoSMoS flood mapping products include likely riverine discharges given the atmospheric conditions driving coastal storms. This means that in the case of a 1% annual chance coastal storm event, CoSMoS results are not showing a 1% annual chance river flooding event, but rather a likely discharge during the modeled 1% annual chance coastal storm event. To understand the possible flooding during a 1% annual chance river flooding event, the FEMA DFIRM maps and additional studies with a more in-depth focus on riverine flooding were used as a basis for mapping the potential future riverine flooding hazard zone.

The mouths of the San Luis Rey River, Buena Vista Lagoon, and Loma Alta Creek are expected to change in several ways in response to sea-level rise. The mouths of these river/creek systems are mostly closed by sand berms. (Note that the mouth of Buena Vista Lagoon is also closed off by a weir). These sand berms are naturally formed by waves, which push sand into the mouths. With higher sea levels, waves may push sand up to higher levels, causing the sand berms to rise in height. When rainfall and runoff cause high flows in the river/creek systems, the high flows can overtop and scour the sand berms, causing the mouths to open and flow directly to the ocean. The combination of higher sand berms and higher ocean water levels due to sea-level rise has the potential to increase flooding at the mouths of these systems during rain events. These processes are complex and have not been previously analyzed in detail. This report relies on an assessment of available information on river/creek flooding from FEMA and CoSMoS as presented in the following sections.

Buena Vista Lagoon

The Buena Vista Lagoon is divided into four major basins by I-5, Carlsbad Boulevard, and the NCTD railroad tracks. There is a weir at the mouth of the lagoon, which restricts tidal flow and the four basins are connected by relatively narrow weir and bridge channels.

As part of the Buena Vista Lagoon Enhancement Project Environmental Impact Report (EIR), Everest International Consultants modeled potential river flooding for a 1% annual chance riverine storm event under two sea-level rise scenarios (2.0 and 5.5 feet) in Buena Vista Lagoon. Results from the modeling included water levels for each basin under each scenario. ESA mapped these water levels on top of the topography of Oceanside to determine flood extents during a 1% annual chance riverine storm event. In areas where the existing FEMA flood map extended beyond the mapped model results, the flood extent was extended to match FEMA.

Loma Alta Slough

Loma Alta Slough is the smallest of the three coastal waterways in Oceanside and remains closed to the ocean by a high beach berm for most of the year. ESA previously developed a hydraulic model of the Loma Alta Slough based on the 1979 FEMA model and an updated survey of the slough bathymetry. Review of the model showed that water levels in Loma Alta Slough are driven by the state of the mouth of the slough; if the mouth is closed, the water levels back up and reach higher elevations than when the mouth is open. The model results showed that, even under the highest sea-level rise scenario (5.7 feet), the mouth elevation controlled the water levels in the slough and not the downstream (ocean) water level. However, as discussed above, sea-level rise is expected to increase the beach berm height, which is not included in the model, and the higher berm could increase flooding.

The FEMA river flood mapping for Loma Alta Slough is based on modeling that assumes that the mouth is closed, which is likely conservative for current conditions, because the mouth would scour during a 1% annual chance riverine flood event, and water levels could be lower than what was modeled. Because the FEMA map represents a conservative current condition, and because an analysis of the complex beach berm processes with sea-level rise is beyond the scope of this project, the FEMA mapping for Loma Alta Slough was used for existing and future conditions for this assessment.

San Luis Rey River

Flood modeling for the San Luis Rey River under sea-level rise scenarios has not been completed, based on ESA's understanding and research. To determine the future potential flood extent of the river, a conservative estimate of potential future flooding was analyzed based on existing FEMA mapping.

Because the edges of the San Luis Rey River floodplain are relatively steep, it was hypothesized that a minor increase in water levels (1 to 5 feet) would not actually increase the extent of flooding dramatically. To confirm this, ESA used the existing conditions FEMA 1% annual chance river flood map overlain on the topography of Oceanside to determine current flood elevations. The flood elevations were then raised by 1 and 5 feet of sea-level rise, as a conservative estimate of how the riverine flooding could increase, and mapped on the topography to approximate the extent of flooding in the future. As hypothesized, in most areas, there was very minimal increase in flood area due to steep banks that confine the river floodplain. In the few instances where the 5-foot vertical increase resulted in substantial lateral expansion of the flood zone, the FEMA 1% annual chance flood extent was extended to include those areas. This expanded FEMA flood extent, assuming 5 feet of sea-level rise, was conservatively used for all of the future sea-level rise scenarios.

4.3 Hazard Zone Methods

The following sections discuss how the data presented in Section 4.1 were used to define the future potential hazard zones (**Figures 4-2 through 4-26**). The Oceanside hazard maps prepared for this report show potential flood risks due to both coastal and river flooding with sea-level rise. Note that this mapping approach is similar to FEMA's approach in mapping current flood risks, in that both mapping approaches show coastal and river flood risks together. The maps do not suggest that a 1% annual chance river flood will occur at the same time as a 1% annual chance coastal flood event (which would be extremely rare), but they do show all of the areas that could be impacted by flooding during one or both events.

4.3.1 Potential Future Ocean Water Levels with Beach Erosion Hazard Zone

This zone was mapped based on the results from CoSMoS. The "hold the line, no beach nourishment" erosion scenario (Section 4.1.1) was used with the tidal inundation flooding scenario (Section 4.1.2) to map the future potential ocean water levels with beach erosion hazard zone at each time step.

4.3.2 Potential Future Coastal Flooding and Waves Hazard Zone

This zone was mapped based on the CoSMoS results. The zone represents areas where the 1% annual chance coastal flood inundation overlaps the 1% annual chance coastal wave runup (e.g., areas that are both inundated and experiencing wave impacts).

4.3.3 Potential Future Coastal and Riverine Flooding Hazard Zone

This zone was mapped by combining the CoSMoS coastal flooding results with the riverine analyses discussed in Section 4.1.4. On the coast, the CoSMoS 1% annual chance coastal flood results were used for each time step. Along the San Luis Rey River, the expanded FEMA flood extent (i.e., 5-foot vertical increase) was used for all of the future time steps (i.e., no change between short term and 2100-2140 scenarios) (Section 4.2.4, San Luis Rey River). At Loma Alta Slough, the existing FEMA flood extent was used for all time steps (i.e., no change between short term and 2100-2140 scenarios) (Section 4.2.4, Loma Alta Slough). For Buena Vista Lagoon, the mapped model results from Everest International Consultants as adjusted by the FEMA map was used at each time step (Section 4.2.4, Buena Vista Lagoon). These four pieces were combined into the potential future coastal and riverine flooding hazard zone.

4.3.4 Potential Future Coastal Flooding Wave Runup Hazard Zone

This zone was mapped based on the results from CoSMoS. The zone represents areas beyond where 1% annual chance coastal flood inundation occurs and only where there is potential wave runup.

4.3.5 Potential Future Development Erosion

This zone was mapped based on the results from CoSMoS. The let it go, no beach nourishment erosion scenario (Section 4.1.1) was used to map future potential development erosion at each time step.

Insert Figures 4-2 through 4-26 starting here. Update TOC manually.

Figure 4-2. Existing Conditions Hazards

Figure 4-3. Existing Conditions Hazards

Figure 4-4. Existing Conditions Hazards

Figure 4-5. Existing Conditions Hazards

Figure 4-6. Existing Conditions Hazards

Figure 4-7. Potential Short Term (2025 - 2040) Hazards

Figure 4-8. Potential Short Term (2025 - 2040) Hazards

Figure 4-9. Potential Short Term (2025 - 2040) Hazards

Figure 4-10. Potential Short Term (2025 - 2040) Hazards

Figure 4-11. Potential Short Term (2025 - 2040) Hazards

Figure 4-12. Potential Mid Term (2040 - 2070) Hazards

Figure 4-13. Potential Mid Term (2040 - 2070) Hazards

Figure 4-14. Potential Mid Term (2040 - 2070) Hazards

Figure 4-15. Potential Mid Term (2040 - 2070) Hazards

Figure 4-16. Potential Mid Term (2040 - 2070) Hazards

Figure 4-17. Potential Long Term (2070 - 2100) Hazards

Figure 4-18. Potential Long Term (2070 - 2100) Hazards

Figure 4-19. Potential Long Term (2070 - 2100) Hazards

Figure 4-20. Potential Long Term (2070 - 2100) Hazards

Figure 4-21. Potential Long Term (2070 - 2100) Hazards

Figure 4-22. Potential 2100 - 2140 Hazards

Figure 4-23. Potential 2100 - 2140 Hazards

Figure 4-24. Potential 2100 - 2140 Hazards

Figure 4-25. Potential 2100 - 2140 Hazards

Figure 4-26. Potential 2100 - 2140 Hazards

Section 5

VULNERABILITY ASSESSMENT

Understanding the risk of not taking action is the first step in planning for sea-level rise.

This section uses the five future hazard zones described in Section 4 to identify the assets potentially at risk from sea-level rise (e.g., homes, roads, utilities). These places or assets, as described in Section 2.2, are categorized into the following asset categories: buildings, infrastructure, hazardous materials, access and recreation, cultural, and natural assets.

In order to develop an Adaptation Plan to address potential sea-level rise vulnerability, the risk of not taking action must be understood first. For this reason, the vulnerability assessment considers a "do nothing" or "no action" scenario in which the City or other asset managers do not respond to sea-level rise. However, in reality, the City will likely take action, and this assessment of vulnerability is the first step in doing so.

5.1 Methodology

Each asset category was analyzed to determine the potential exposure to the different hazard areas and consequences, and the sensitivity and adaptive capacity of the assets to the potential hazard, as per the CCC guidelines. The results of this analysis are summarized in tables provided in Section 5.2 for each asset category. The following sections describe in further detail the information contained within each of these tables. The CCC guidelines also recommend consideration of land use constraints (e.g., how land use patterns may impact potential sea-level rise vulnerability), which will be analyzed and presented in the Adaptation Plan.

5.1.1 Asset

The first row of each table describes the types of assets in a particular category and provides details relevant to Oceanside. For example, in the transportation category, major transportation corridors and their location are identified and described.

Exposure to hazard is evaluated based on the type of hazard zone an asset would potentially be subject to under future conditions and the timing at which this hazard is expected to potentially occur.

5.1.2 Potential Exposure to Hazard and Consequences

To assess exposure to hazards, the assets in different categories were intersected in GIS with each potential future hazard zone. Point assets (like Police Stations) in each potential future hazard zone were counted, linear assets (like roads and pipelines) were measured by mile, and planar assets (like wetland areas) were measured by acre. A summary of these results is reported in the second row of the tables in the following sections. The full set of results is provided in tabular form in **Appendix C**. Figures for each category follow the summary tables.

To further characterize an asset's exposure to hazards, a *hazard exposure grade* of low, medium, or high potential hazard exposure was assigned. This grade was assigned after quantifying the asset's exposure and is dependent on both timeframe (e.g., if an asset could potentially flood in the near-term it would have a higher hazard exposure grade than one that could flood in the long-term) and the potential level of severity posed by the type of hazard zone. The five potential future hazard zones described in Section 4 represent different levels of severity and consequences as further described below:

1. Areas subject to the potential future ocean water levels with beach erosion hazard zone would be lost entirely.
2. Areas in the potential future coastal flooding and waves hazard zone would likely be heavily damaged during coastal storms.
3. Areas in the potential future coastal and riverine flooding hazard zone would likely be damaged, but could be recoverable.
4. Areas in the potential future coastal flooding wave runup hazard zone would likely be damaged, but could be recoverable, and would return to service when waves and floodwaters recede.
5. Developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. As discussed in Section 4, this is included to depict a "worst-case" scenario to have a better understanding of what impacts could be if no action were taken, even though no action is unlikely. For this reason, it is not included in the hazard exposure grade determination, but is presented in the tables in Appendix C and the maps within this section.

The hazard exposure grading scheme is provided in **Table 5-1**.

Table 5-1. Hazard Exposure Grading

Timeframe	Potential Future Ocean Water Levels with Beach Erosion	Potential Future Coastal Flooding and Waves	Potential Future Coastal and Riverine Flooding	Potential Future Coastal Flooding Wave Runup
Short-term	High	High	High	Medium
Mid-term	High	Medium	Medium	Medium
Long-term	Medium	Medium	Medium	Low
Longer-term (2100-2140)	Medium	Low	Low	Low

5.1.3 Sensitivity to Hazard and Adaptive Capacity

Sensitivity to hazard is defined as the asset's level of impairment if flooded temporarily or permanently, or if affected by erosion or waves.

Adaptive Capacity is the asset's ability to change and respond to a hazard.

In the third row of each table, an asset's sensitivity, or the asset's level of impairment if flooded or affected by erosion or waves, as well as adaptive capacity, is discussed. In general, assets that are highly sensitive (and have low adaptive capacity) would lose their primary function if exposed to any degree of flood or erosion whatsoever. If assets can maintain their primary function(s) during inundation, they would have low sensitivity (and high adaptive capacity). If assets would lose only part of their function, it is considered, for the purposes of this assessment, moderately sensitive. For example, one of the sensitivities of impacts to transportation corridors is the disruption of vehicular access critical for the provision of emergency services, which would mean the asset has a high sensitivity.

Similar to the hazard exposure grades, a *hazard sensitivity grade* is determined for each asset. **Table 5-2** presents the grading scheme.

Table 5-2. Hazard Sensitivity Grading

Considerations	Score
The given hazard would have no or a low impact on the asset and the primary function of the asset could be maintained. The asset would be able to rebound from the impact quickly (e.g., high adaptive capacity).	Low
The given hazard would cause minor damage or temporary operational interruption.	Medium
The given hazard would cause major damage or long-term operational interruption. The asset would require significant effort to rebound from the impact (e.g. low adaptive capacity).	High

5.1.4 Vulnerability Summary

The last row of each table identifies the overall vulnerability of the asset categories to potential future tidal inundation, storm flooding, waves, and erosion, as determined by the analysis. The overall vulnerability was determined based on the combination of an asset's vulnerability components (exposure to hazard and sensitivity to hazard). In general, if both components are 'low', then the final vulnerability will be 'low.' If both are 'high,' then the final vulnerability is 'high.' In between, there are cases that will be 'moderate,' depending on the combination of components. The vulnerability summaries are indications of the degree of potential vulnerability, not rankings or priorities.

5.2 Potential Oceanside Vulnerabilities

5.2.1 Building Assets

Commercial Buildings

Asset	A range of commercial buildings exist within the coastal zone in Oceanside, including: ▪ Commercial retail/offices; ▪ General industrial; ▪ Mixed-use; and ▪ Hotels and lodging.
Exposure to Hazard and Consequences	The GIS analysis shows that the following building assets could be potentially impacted (short-term to 2100 - 2140 timeframe): ▪ 3 – 6 hotels and lodging facilities (3 under current conditions); ▪ 9 industrial buildings (9 under current conditions); and ▪ 24 commercial retail/office buildings (24 under current conditions). Based on available asset data, no mixed use buildings fall within the hazard zones identified for this sea-level rise vulnerability assessment.
	Hazard exposure grade: ▪ Hotels and lodgings: High (3), Medium (2), Low (1) ▪ Industrial buildings: High (9) ▪ Commercial retail/office buildings: High (24)
Sensitivity to Hazard and Adaptive Capacity	▪ Increased frequency of flooding of buildings leading to water damage and other flood related damages. ▪ Long-term operational interruption if flooding or mechanical and plumbing systems are present on the ground floor and are subject to damage. ▪ Disrupted access to and from buildings.
	Sensitivity grade: High
Vulnerability Summary	▪ Hotels and lodgings: High (3), Medium-High (2), Medium (1) ▪ Industrial buildings: High (9) ▪ Commercial retail/office buildings: High (24)

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Community and Institutional Buildings

Asset	A range of community and institutional buildings exist within the coastal zone in Oceanside, including: ▪ Schools and religious facilities; ▪ Child care facilities; ▪ Health care facilities; ▪ Colleges, schools, and libraries; and ▪ Recreation buildings (e.g., Junior Seau Rec Center and Oceanside Harbor recreational activity buildings).
Exposure to Hazard and Consequences	The GIS analysis shows that the following building assets could be potentially impacted (short-term to 2100 - 2140 timeframe): ▪ 19 – 28 recreation buildings (13 under current conditions). Based on available asset data, no colleges, libraries, schools, religious facilities, nor child care facilities, fall within the hazard zones identified for this sea-level rise vulnerability assessment. There are no health care facilities in the coastal zone.
	Hazard exposure grade: ▪ Recreation buildings: High (15), Medium (6), Low (7)
Sensitivity to Hazard and Adaptive Capacity	▪ Disrupted access to and from the buildings. ▪ Increased frequency of flooding of buildings leading to water damage and other flood related damages.
	Sensitivity grade: Medium
Vulnerability Summary	▪ Recreation buildings: Medium-High (15), Medium (6), Medium-Low (7)

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Residential Buildings

Asset	A range of residential buildings exist within the coastal zone in Oceanside, including: ▪ Single-family residential; ▪ Multi-family residential; ▪ Mobile home parks; and ▪ RV parks.
Exposure to Hazard and Consequences	The GIS analysis shows that the following building assets could be potentially impacted (short-term to 2100 - 2140 timeframe): ▪ 191 – 291 single-family/multi-family residential buildings (164 under current conditions); ▪ 172 mobile homes (172 under current conditions); and ▪ 184 RV Park sites (184 under current conditions).
	Hazard exposure grade: ▪ Residential buildings: High (119), Medium (2), Low (170) ▪ Mobile Homes: High (172) ▪ RV Park sites: High (184)
Sensitivity to Hazard and Adaptive Capacity	▪ Disrupted access to and from the buildings. ▪ Increased frequency of flooding of buildings leading to water damage and other flood related damages.
	Sensitivity grade: ▪ Residential buildings: Medium ▪ Mobile Homes: Low ▪ RV Park sites: Low
Vulnerability Summary	▪ Residential buildings: Medium-High (119), Medium (2), Medium-Low (170) ▪ Mobile Homes: Medium (172) ▪ RV Park sites: Medium (184)

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Emergency Response Facilities

Asset	Several types of emergency response buildings and infrastructure exist in Oceanside: ▪ Fire Stations; ▪ Police Stations; ▪ Emergency Shelter Sites; and ▪ Lifeguard Headquarters.
Exposure to Hazard and Consequences	The Lifeguard Headquarters is in the potential future coastal flooding wave runup hazard zone in the short-term and the potential future coastal flooding hazard zone in the long-term. Based on available asset data, no emergency shelter sites, fire stations, nor police stations fall within the coastal zone.
	Hazard exposure grade: ▪ Lifeguard Headquarters: Medium
Sensitivity to Hazard and Adaptive Capacity	▪ Increased frequency of flooding of the Lifeguard Headquarters leading to water damage and other flood related damages. ▪ Flooding and erosion may impact emergency response capabilities and response time.
	Sensitivity grade: High
Vulnerability Summary	Lifeguard Headquarters: Medium-High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Figure 5-1. Building Asset Exposure Map

Figure 5-2. Building Asset Exposure Map

Figure 5-3. Building Asset Exposure Map

Figure 5-4. Building Asset Exposure Map

Figure 5-5. Building Asset Exposure Map

5.2.2 Infrastructure Assets (Community and Water-Related)

Transportation

Asset	Several major transportation corridors pass through Oceanside: ▪ I-5 passes north-south through the city of Oceanside and is a critical transportation facility in California. ▪ California State Route 78 runs east-west from I-5 at the Oceanside/Carlsbad border to Blythe, CA. ▪ California State Route 76/San Luis Rey Mission Expressway runs east-west in the north portion of the city. ▪ There are many smaller surface streets in the area, which provide access to local businesses, residences, and the coast. ▪ The NCTD railroad passes north-south through the city and is a critical transportation facility in Southern California. A spur of the railroad parallels Oceanside Blvd and accommodates the NCTD "Sprinter" service to Vista, San Marcos, and Escondido.
Exposure to Hazard and Consequences	The GIS analysis shows that the following routes could be impacted (see Appendix D for further details): ▪ S. Coast Highway: High ▪ CA Route 78: High ▪ CA Route 76: High ▪ Railroad: High ▪ I-5: None ▪ Harbor Drive: High ▪ N. Pacific Street: High ▪ Capistrano Drive: High ▪ Loretta Street: High ▪ N. Coast Village Way: High ▪ Breakwater Way: High ▪ The Strand: High ▪ Mira Mar Place: High ▪ Surfrider Way: High ▪ Seagaze Drive: Medium ▪ Wisconsin Avenue: High ▪ Hayes Street: Medium ▪ S. Pacific Street: High ▪ Morse Street: Medium ▪ St. Malo Beach: High ▪ S. Vista Way: High
	Hazard exposure grade: Low to High depending on road
Sensitivity to Hazard and Adaptive Capacity	▪ Disrupt access pathways critical for emergency services. ▪ Disrupt transportation links to local businesses, residences, and municipal infrastructure. ▪ Damage to existing roadways and related infrastructure due to scour and erosion of embankments, footings and other structural/ geotechnical elements.
	Sensitivity grade: ▪ Local roads: Medium ▪ S. Coast Hwy, I-5, CA Routes 78 and 76, and railroad: High
Vulnerability Summary	▪ Local roads: Medium to Medium-High ▪ S. Coast Highway and California State Routes 78 and 76: High ▪ I-5: None ▪ Railroad: High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Coastal Structures

Asset	Several types of coastal structures exist in Oceanside: ▪ Shoreline protective devices (seawalls, riprap); ▪ San Luis Rey River levees and floodwalls; ▪ San Luis Rey River groin; and ▪ Oceanside Harbor jetties and breakwaters.
Exposure to Hazard and Consequences	All of the coastal structures are specifically designed and intentionally located to be in the hazard zones. However, over time, the exposure of the structures will likely increase, so that riprap that experiences occasional flooding today could experience deeper floodwaters and stronger wave action in the future. ▪ Shoreline protective devices: High ▪ San Luis Rey River levees and floodwalls: Medium ▪ San Luis Rey River groin: High ▪ Oceanside Harbor jetties and breakwaters: High
	Hazard exposure grade: Medium to High depending on structure
Sensitivity to Hazard and Adaptive Capacity	Coastal structures are designed to be in hazard zones, however: ▪ Increased water levels and wave-runup during storms can cause damage to the structures; and ▪ Increased erosion of riprap can lead to incremental reduction in the level of flood protection and/or increased maintenance costs.
	Sensitivity grade: ▪ Low (assuming some level of maintenance) ▪ Oceanside Harbor jetties and breakwaters: Medium
Vulnerability Summary	▪ Shoreline protective devices: Medium ▪ San Luis Rey levees and floodwalls: Medium-Low ▪ San Luis Rey River groin: Medium ▪ Oceanside Harbor jetties and breakwaters: Medium-High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Communications

Asset	Communication assets within the coastal zone include cell phone towers and phone lines.
Exposure to Hazard and Consequences	Based on the available asset data, there is only one cell phone tower within the coastal zone, and it does not fall within the potential hazard zones identified for this assessment. The telephone line network within the coastal zone is currently not available in GIS format.
	Hazard exposure grade: None
Sensitivity to Hazard and Adaptive Capacity	▪ Increased risk of erosion or storm damage which could damage or down the tower and cause delays in communication.
	Sensitivity grade: Low
Vulnerability Summary	None

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Energy

Asset	Energy assets within the coastal zone include a natural gas line that runs parallel to the shore and electrical transmission lines in the northern part of the city.
Exposure to Hazard and Consequences	Both the natural gas line and the transmission lines are inland of all of the mapped potential future hazards. The natural gas line crosses all three lagoons and would be exposed to increased riverine flooding at those crossings. The transmission lines cross the San Luis Rey River and would be exposed to increased riverine flooding at that crossing.
	Hazard exposure grade: Low
Sensitivity to Hazard and Adaptive Capacity	▪ Increased risk of erosion or storm damage which could damage or down the transmission towers and cause service disruptions. ▪ Rising ground water levels may place unanticipated buoyancy forces on buried natural gas pipeline, potentially leading to leaks and/or pipe failure.
	Sensitivity grade: High
Vulnerability Summary	Medium

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Emergency Response Facilities

Asset	Emergency response infrastructure assets within the coastal zone include fire hydrants.
Exposure to Hazard and Consequences	In the short-term, 47 fire hydrants fall within the potential future hazard zones. This number increases to 54 in the mid-term, 62 in the long-term, and 65 in the 2100 - 2140 time frame. Thirty-nine fire hydrants fall within the hazard zones under current conditions
	Hazard exposure grade: Low to High depending on the individual asset
Sensitivity to Hazard and Adaptive Capacity	▪ Increased risk of erosion or storm damage which could damage the fire hydrant. ▪ Rising surface waters may limit access to hydrants for emergency response and maintenance.
	Sensitivity grade: High
Vulnerability Summary	Medium-High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Figure 5-6. Community Infrastructure Asset Map

Figure 5-7. Community Infrastructure Asset Map

Figure 5-8. Community Infrastructure Asset Map

Figure 5-9. Community Infrastructure Asset Map

Figure 5-10. Community Infrastructure Exposure Map

Stormwater

Asset	The municipal storm drain system serves coastal communities in Oceanside. The system includes storm cleanouts, storm inlets, storm outlets, storm drains, and system nodes.
Exposure to Hazard and Consequences	The analysis shows that the following assets would potentially be impacted (short-term to 2100 - 2140 timeframe): ▪ 28 – 31 storm cleanouts (28 under current conditions); ▪ 168 – 210 storm drain inlets (150 under current conditions); ▪ 19 – 20 storm nodes (17 under current conditions); ▪ 133 storm drain outlets (133 under current conditions); and ▪ 4.2 – 4.9 miles of storm drains (4.0 miles under current conditions).
	Hazard exposure grade: Low to High depending on individual asset
Sensitivity to Hazard and Adaptive Capacity	▪ Blockage of inlets or outlets. Tide gates are particularly susceptible to blockage due to high downstream water levels. ▪ Backwater effects due to downstream flow blockage or constrictions. ▪ Insufficient capacity for (potentially) increased rainfall. ▪ Failure of storm drainage system may cause flooding inland of the coast and associated property damage. ▪ Failure of storm drainage system may cause impacts to water quality
	Sensitivity grade: Medium
Vulnerability Summary	Medium

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Wastewater

Asset	Sanitary sewer pipes, pumping stations, and treatment plants are essential to the function of the municipal sewer system. In the coastal zone, the wastewater system infrastructure includes sewer lines and laterals, outfalls, control valves, fittings, manholes, and other sewer structures.
Exposure to Hazard and Consequences	The analysis shows that the following assets would potentially be impacted (short-term to 2100 - 2140 timeframe): ▪ 2 sewer control valves (flow regulators, 2 under current conditions); ▪ 6 – 14 sewer fittings (pipe connectors, 5 under current conditions); ▪ 110 – 135 sewer manholes (93 under current conditions); ▪ 7 – 12 sewer structures (7 under current conditions); ▪ 0.7 – 0.8 miles of sewer laterals (0.6 miles under current conditions); ▪ 6.8 – 8.2 miles of sewer lines (6.3 miles under current conditions); and ▪ 0.7 miles of sewer outfalls (0.7 miles under current conditions). Two buildings associated with the La Salina Wastewater Treatment Plant occur in a hazard zone, one under existing conditions.
	Hazard exposure grade: ▪ Low to High depending on asset ▪ La Salina Wastewater Treatment Plant: High
Sensitivity to Hazard and Adaptive Capacity	▪ Increased risk of flooding/inundation of critical infrastructure (pumps, utilities), disrupting operations and potentially damaging equipment. ▪ Rising surface waters may limit access to facilities and pipelines for maintenance and operations. ▪ Rising ground water levels may place unanticipated buoyancy forces on buried pipelines, potentially leading to leaks and/or pipe failure. ▪ Failure of wastewater system may cause impacts to water quality
	Sensitivity grade: ▪ Structures: Medium ▪ La Salina Wastewater Treatment Plant: High
Vulnerability Summary	▪ Structures: Medium ▪ La Salina Wastewater Treatment Plant: High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Water

Asset	Water mains and pipes, pumping stations, wells, and treatment plants are essential to the function of the municipal water system.
Exposure to Hazard and Consequences	The analysis shows that the following assets would potentially be impacted (short-term to 2100 - 2140 timeframe): ▪ 67 – 77 water fittings (pipe connectors, 60 under current conditions); ▪ 183 – 232 water meters (159 under current conditions); ▪ 7 – 12 pump stations (7 under current conditions); ▪ 137 – 175 system valves (regulate flow, 120 under current conditions); ▪ 3 wells (3 under current conditions); ▪ 5.5 – 7.1 miles of water main (4.9 miles under current conditions); and ▪ 0.7 – 0.9 miles of water service (0.6 miles of water service). Based on the available asset data, no water pumps fall within the hazard zones identified for this assessment. No treatment plants are present within the coastal zone.
	Hazard exposure grade: Low to High depending on asset
Sensitivity to Hazard and Adaptive Capacity	▪ Increased risk of flooding/inundation of critical infrastructure (pumps, utilities), disrupting operations and potentially damaging equipment. ▪ Rising surface waters may limit access to facilities and pipelines for maintenance and operations. ▪ Rising ground water levels may place unanticipated buoyancy forces on buried pipelines, potentially leading to leaks and/or pipe failure. ▪ Failure of water system may cause impacts to water quality
	Sensitivity grade: Medium
Vulnerability Summary	Medium

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Figure 5-11. Water-Related Infrastructure Assets

Figure 5-12. Water-Related Infrastructure Assets

Figure 5-13. Water-Related Infrastructure Assets

Figure 5-14. Water-Related Infrastructure Assets

Figure 5-15. Water-Related Infrastructure Assets

5.2.3 Hazardous Materials

	Hazardous Materials
Asset	There are multiple Leaking Underground Storage Tanks (LUST) that store petroleum or other hazardous substances within and adjacent to the coastal zone[4]. Additionally, multiple gas stations exist within the coastal zone.
Exposure to Hazard and Consequences	One LUST location, Tri-City Plating, Incorporated, exists in the current 100-year flood zone for the Loma Alta Slough. The location may be subject to perchlorate contamination. The site has been tested and found to be contaminated with volatile organic compounds (e.g., Chloroform, Tetrachloroethylene (PCE)). One gas station, the Oceanside Harbor Fuel Dock and Mini Mart, lies within the current ocean water level hazard zone. However, the fuel dock is designed to be in this zone in order to fuel boats in the Oceanside Harbor.
	Hazard exposure grade: Low
Sensitivity to Hazard and Adaptive Capacity	Increased flood risk may increase the likelihood of an accidental hazardous material release, depending on the storage facility location, material type, and storage configuration. Hazardous materials which are water-soluble or which react with water, materials which are stored in non-waterproof containers, and materials which are stored in buildings which have an elevated risk of flood damage are expected to have the greatest risk of accidental release during a flood event. An accidental release of hazardous materials may lead to the: ▪ Mobilization of hazardous materials in surface water; ▪ Mobilization of hazardous materials in groundwater; ▪ Airborne/Aerosol release of hazardous materials; and ▪ Contamination of soils. Such a release may expose humans and wildlife to toxic, corrosive, or otherwise harmful materials. The consequences of exposure can vary greatly depending on the type of hazardous material, and the mode, duration, and amount of exposure.
	Sensitivity grade: High
Vulnerability Summary	Medium

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

[4] https://www.envirostor.dtsc.ca.gov/public/

Figure 5-16. Hazardous Materials Asset Exposure Map

Figure 5-17. Hazardous Materials Asset Exposure Map

Figure 5-18. Hazardous Materials Asset Exposure Map

Figure 5-19. Hazardous Materials Asset Exposure Map

Figure 5-20. Hazardous Materials Asset Exposure Map

5.2.4 Recreation and Visitor-Serving Assets

Recreation and Visitor-Serving

Asset	Recreation and visitor-serving assets in Oceanside's coastal zone include: ▪ Parks; ▪ Bicycle routes; ▪ Trails; ▪ Beach access points and beaches; ▪ Oceanside Pier; ▪ Hotels and lodging; ▪ Recreation buildings; and ▪ RV Park sites.
Exposure to Hazard and Consequences	The analysis shows that the following assets would potentially be impacted (short-term to 2100 - 2140 timeframe): ▪ 19 – 24 acres of parks (18 acres under current conditions); ▪ 3.2 – 3.5 miles of bicycle routes (2.9 miles under current conditions); ▪ 5.8 – 5.9 miles of trails (5.6 miles of trails under current conditions); and ▪ 19 – 24 beach access points (17 under current conditions); ▪ 38 – 40 acres of beach; ▪ 3 – 6 hotels and lodging facilities (3 under current conditions); ▪ 19 – 28 recreation buildings (13 under current conditions); and ▪ 184 RV Parks sites (184 under current conditions). The Oceanside Pier is specifically designed and intentionally located to be in the potential hazard zones. However, over time, the exposure of the structure will increase, so the Oceanside Pier is categorized as high exposure.
	Hazard exposure grade: ▪ Low to High depending on the asset ▪ Oceanside Pier: High ▪ Hotels and lodgings: High (3), Medium (2), Low (1) ▪ Recreation buildings: High (15), Medium (6), Low (7) ▪ RV Park sites: High (184)
Sensitivity to Hazard and Adaptive Capacity	▪ Increased frequency of flooding and erosion leading to water damage and other flood related damages. ▪ Loss of coastal access due to inundation of coastal access ways. ▪ Loss of access to recreational amenities due to inundation of parks and other facilities. ▪ Loss of mobility for pedestrian and bicyclists within the coastal zone due to inundation of segments of existing and planned sidewalks, paths, and trails. ▪ Access to the Oceanside Pier would cease during flood events, disrupting operations on a short-term basis.

	Sensitivity grade: ▪ Coastal access and recreation assets: Low-Medium ▪ Oceanside Pier: Medium (assuming some level of maintenance) ▪ Hotels and lodging buildings: High ▪ Recreation buildings: Medium ▪ RV Park sites: Low
Vulnerability Summary	▪ Coastal access and recreation assets: Low to Medium-High ▪ Oceanside Pier: Medium-High ▪ Hotels and lodging buildings: High (3), Medium-High (2), Medium (1) ▪ Commercial/retail buildings: High (24) ▪ Recreation buildings: Medium-High (19), Medium (5), Low-Medium (12) ▪ RV Park sites: Medium (184)

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Oceanside Small Craft Harbor

Asset	The Oceanside Small Craft Harbor is a key recreational and commercial asset in Oceanside, which includes recreational buildings (Section 5.2.1) and transportation and other infrastructure (Section 5.2.2). Although discussed in previous sections, these assets have been collated in this table to understand vulnerabilities specific to Oceanside Harbor. The assets include: ▪ Harbor Drive; ▪ N. Pacific Street; ▪ Bicycle routes; ▪ Trails; ▪ 28 recreation buildings; ▪ 1 gas station; ▪ 32 fire hydrants; ▪ 35 water fittings; ▪ 57 water system valves; ▪ 5 lift stations; ▪ 87 water meters; ▪ Water mains; ▪ Water service; ▪ 8 sewer fittings; ▪ 18 sewer manholes; ▪ 5 sewer structures; ▪ Sewer lines; ▪ 4 storm cleanouts; ▪ 2 storm inlets; ▪ 2 storm nodes; ▪ 53 storm outlets; and ▪ Storm drains.
Exposure to Hazard and Consequences	In the short-term, 79 of the 100 acres in the Harbor fall within the potential future hazard zones. This increases to 86 acres in the mid-term and to 93 acres in the long-term and 2100 - 2140 time frame.
	Hazard exposure grade: High
Sensitivity to Hazard and Adaptive Capacity	▪ Increased frequency of flooding and erosion leading to water damage and other flood related damages; ▪ Disrupted access to and from buildings and associated recreational and commercial services; and ▪ Disrupted access and damage to boats and docks.
	Sensitivity grade: High
Vulnerability Summary	High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

5.2.5 Cultural Assets

Asset	Cultural resources are defined as prehistoric and historic period sites, structures, districts, landscapes, or any other physical evidence associated with human activity considered important to a culture, subculture, or community. In Oceanside, cultural assets include: ▪ Archeological resources (shell middens, scatters, lithic scatter, and refuse deposits); ▪ Historic-period built resources; ▪ Native American cultural resources; ▪ Paleontological resources (fossilized impression plants, fossilized marine invertebrates and terrestrial mammals); and ▪ Cemeteries. See Section 2.1.6 of the Background Study for further details on cultural resources in Oceanside.
Exposure to Hazard and Consequences	The historic-period built resources at 305 and 704 N. The Strand, (Oceanside Bath House and Roberts Cottages) are at risk of exposure under current conditions. The Oceanside Municipal Pier (discussed in Section 5.2.4, Recreation and Visitor-Serving) is also considered a historic-period built resource. Based on the available asset data, no other cultural resources are located in the potential hazard zones identified in this assessment.
	Hazard exposure grade: High
Sensitivity to Hazard and Adaptive Capacity	Increased frequency of floods and erosion could eliminate the historic and archeological sites, and threaten the preservation of cultural resources in the area.
	Sensitivity grade: High
Vulnerability Summary	High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Figure 5-21. Recreation, Visitor-Serving and Cultural Resources Asset Exposure Maps

Figure 5-22. Recreation, Visitor-Serving and Cultural Resources Asset Exposure Maps

Figure 5-23. Recreation, Visitor-Serving and Cultural Resources Asset Exposure Maps

Figure 5-24. Recreation, Visitor-Serving and Cultural Resources Asset Exposure Maps

Figure 5-25. Recreation, Visitor-Serving and Cultural Resources Asset Exposure Maps

5.2.6 Natural Resources

Shorelines and Preserves

Asset	Some of the natural assets within the coastal zone in Oceanside include beaches, bluffs, and preserves. Preserve areas are identified in the Draft Oceanside Subarea Plan and correspond to conservation areas with varying degrees of protection (softline preserve and hardline preserve). See the Background Study for more detail.
Exposure to Hazard and Consequences	Natural assets tend to be resilient to storm events, but can still be impacted by sea-level rise and erosion. The analysis shows that the following assets could fall within the ocean water levels and beach erosion hazard zone (short-term to 2100 - 2140 timeframe) assuming "holding the line" management: ▪ 38 – 40 acres of beach; ▪ 1 acre of coastal bluffs; ▪ 20 acres of softline preserve; and ▪ 138 – 139 acres of hardline preserve.
	Hazard exposure grade: Medium
Sensitivity to Hazard and Adaptive Capacity	While most of the habitats already experience some amount of inundation, increased erosion and flooding may change habitats and the species that can establish in those areas.
	Sensitivity grade: Low to High
Vulnerability Summary	Medium-Low to Medium-High

Note: maintaining an armored/developed shoreline (as assumed by the "hold the line" scenario) would result in erosion of the beach. If armoring and development is not maintained, the beach migration into these areas could be allowed/facilitated and the beach could persist longer.

Critical Species Habitat

Asset	Critical species within the coastal zone in Oceanside include Coastal California gnatcatcher, Least Bell's, and southwestern willow flycatcher.
Exposure to Hazard and Consequences	Natural assets, including critical habitats, tend to be resilient to storm events, but can still be impacted by sea-level rise and erosion. The analysis shows that the following critical species assets would fall within the ocean water levels and potential beach erosion hazard zone (short-term to 2100-2140 timeframe) assuming "holding the line" management: ▪ 171 acres of Coastal California gnatcatcher habitat; ▪ 74 acres of Least Bell's vireo habitat; and ▪ 81 acres of Southwestern willow flycatcher habitat. Other critical species' habitats will likely be impacted as well, but GIS habitat areas were not available, beyond the discussion above.
	Hazard exposure grade: Medium
Sensitivity to Hazard and Adaptive Capacity	How these species respond to changes in habitat are hard to predict, but it is likely that suitable habitat areas will decrease over time.
	Sensitivity grade: Low to High
Vulnerability Summary	Medium-Low to Medium-High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Wetlands

Asset	Natural assets within the coastal zone include wetlands.
Exposure to Hazard and Consequences	Natural assets tend to be resilient to storm events, but can still be impacted by sea-level rise and erosion. The analysis shows that the following assets would fall within the ocean water levels and potential beach erosion hazard zone (short-term to 2100-2140 timeframe) assuming "holding the line" management: ▪ 58 acres of estuarine and marine wetland; ▪ 28 acres of freshwater emergent wetland; and ▪ 44 acres of freshwater forested/shrub wetland.
	Hazard exposure grade: Medium
Sensitivity to Hazard and Adaptive Capacity	While most of the habitats already experience some amount of inundation, increased erosion and flooding may change habitats and the species that can establish in those areas (e.g., salt marsh vegetation species tend to establish at elevations dependent on inundation frequency. With sea-level rise, if certain plant species are inundated too frequently, they will drown out, and other plant species who can be exposed to more frequent inundation can establish).
	Sensitivity grade: Low to High
Vulnerability Summary	Medium-Low to Medium-High

Note: developed areas subject to the potential future development erosion hazard zone would be lost entirely if no management actions are taken. Since action is likely, the potential future development erosion hazard is not included in the hazard exposure grade determination.

Figure 5-26. Natural Resource Asset Hazard Exposure Maps

Figure 5-27. Natural Resource Asset Hazard Exposure Maps

Figure 5-28. Natural Resource Asset Hazard Exposure Maps

Figure 5-29. Natural Resource Asset Hazard Exposure Maps

Figure 5-30. Natural Resource Asset Hazard Exposure Maps

Section 6

SUMMARY

With anticipated sea-level rise, Oceanside's current vulnerabilities to coastal flooding and erosion are projected to increase in frequency, intensity, and extent. There are many currently at-risk assets in the coastal zone that may experience increased exposure to hazards. There are also many assets that are not currently subject to flooding, which may be subject to flooding under projected future conditions. **Table 6-1** summarizes the grades for each asset category's exposure to hazard, sensitivity to hazard, and overall vulnerability.

Commercial Buildings	Hotels and Lodgings			
	Industrial Buildings			
	Commercial Buildings			
Community Buildings	Recreation Buildings			
Residential Buildings	Single and Multi-Family Homes (*Primarily adjacent to the Buena Vista Lagoon, south of Harbor, and beachfront properties along most of the coast*)			
	Mobile Homes (*Along Loma Alta Creek*)			
	RV Park Sites			
Emergency Response Facilities	Lifeguard Headquarters			

Table 6-1. Summary of Vulnerability

Transportation	Local Roads: ▪ Seagaze Drive ▪ Hayes Street ▪ Morse Street
	Local Roads: ▪ Harbor Drive ▪ N. Pacific Street ▪ Capistrano Drive ▪ Loretta Street ▪ N. Coast Village Way ▪ Breakwater Way ▪ The Strand ▪ Mira Mar Place ▪ Surfrider Way ▪ Wisconsin Avenue ▪ S. Pacific Street ▪ St. Malo Beach ▪ S. Vista Way
	Major Transportation Routes: ▪ S. Coast Highway ▪ CA Routes 78 and 76 ▪ Railroad
Coastal Structures	Shoreline protective devices
	San Luis Rey River levees and floodwalls
	San Luis Rey River groin
	Oceanside Harbor jetties and breakwaters
Communications	Structures
Energy	Natural gas line
Emergency Response Facilities	Fire hydrants
Stormwater	Structures (i.e., cleanouts, inlets, nodes, outlets, storm drains)
Wastewater	Structures (i.e., control valves, fittings, manholes, laterals, lines, outfalls, and other structures)
	La Salina Wastewater Treatment Plant

Table 6-1. Summary of Vulnerability

Asset Category	Asset	Potential Exposure to Hazard	Sensitivity to Hazard	Vulnerability
Water	Structures (i.e., fittings, meters, pump stations, system valves, wells, mains, water service)	Low to High	Medium	**Medium**
Hazardous Materials	LUSTs and Gas stations	Low	High	**Medium**
Recreation and Visitor-Serving Assets				
Visitor-Serving	Parks, bicycle routes, trails, and beach access points	Low to High	Low to Medium	**Medium**
	Beaches	Medium	Medium	**Medium**
	Hotels and lodging, recreational buildings, RV Park sites (see detail above)	Low to High	Medium to High	**Medium-High**
	Oceanside Pier	High	Medium	**Medium-High**
Oceanside Small Craft Harbor Assets	Roads, buildings, infrastructure	High	High	**High**
Cultural Assets	Historic-period built resources	High	High	**High**
Natural Resources				
Shorelines and Preserves	Beaches, bluffs, and preserves	Medium	Low to High	**Medium-Low to Medium-High**
Critical Species Habitat	Gnatcatcher, Least Bell's vireo, and Southwestern willow flycatcher habitat	Medium	Low to High	**Medium-Low to Medium-High**
Wetlands	Estuarine and marine, freshwater emergent, and freshwater forested/shrub wetlands	Medium	Low to High	**Medium-Low to Medium-High**

The following are the publicly-owned assets most vulnerable to sea-level rise hazards (i.e., received an overall vulnerability ranking of high or medium-high):

- **S. Coast Highway, California Routes 78 and 76, and the Railroad:** All of these transportation corridors already experience flooding under current conditions during a 1% annual chance riverine flood event. Flooding of any of these routes would cause major service disruption for the City of Oceanside. With sea-level rise, the flood extent is expected to increase and flooding will become more frequent.
- **La Salina Wastewater Treatment Plant:** The treatment plant is already in the 1% annual chance riverine flood zone for Loma Alta Slough. Flooding of the plant would likely cause major service disruption. With

sea-level rise, the flood extent is expected to increase and flooding will become more frequent.

- **Oceanside Small Craft Harbor:** Roughly 80% of the Harbor is expected to fall within one of the hazard zones in the short-term. Regular flooding of the Harbor could impact docks, roads, and buildings and would likely result in a significant economic impact to the City. Regular flooding would also result in a loss of access and recreation.
- **Recreational Buildings:** In the short-term, 15 recreation buildings are projected to experience coastal flooding or regular ocean water inundation. Most of the impacted recreation buildings are adjacent to the Harbor. Regular flooding of recreational building could impact operations and tourism, in some cases permanently.
- **Lifeguard Headquarters:** The lifeguard headquarters is projected to experience coastal wave runup in the short-term and coastal flooding in the long-term. Flooding of the headquarters would likely cause a service disruption, potentially at a time (during a flood event) when lifeguard services are in high demand.
- **Local Roads:** Thirteen local roads are projected to experience coastal and/or riverine flooding in the short-term. Flooding of these roads could disrupt access pathways critical for providing emergency services, or access to local businesses, residences, and/or municipal infrastructure. With sea-level rise, the flood extent is expected to increase and flooding will become more frequent.
- **Oceanside Harbor Jetties and Breakwater:** The Oceanside Harbor jetties and breakwater are currently within the hazard zones as coastal structures. Flooding and erosion/damage of the structures could lead to a reduction in the level of flood protection that they provide, which in turn would result in more flooding and erosion of the Oceanside Harbor and adjacent beaches.
- **Fire Hydrants:** Forty-seven fire hydrants are projected to experience coastal and riverine flooding or regular ocean water inundation in the short-term. Flooding of the fire hydrants would limit access for emergency response and maintenance.
- **Oceanside Pier:** The Oceanside Pier is currently within the hazard zones as a coastal structure. Flooding and water damage could lead to disruption of operations and impacts to public access to the coast.

The following are non-publicly-owned assets most vulnerable to sea-level hazards (i.e., received an overall vulnerability ranking of high or medium-high):

- **Hotels and Lodgings, Industrial, and Commercial Buildings:** Three hotels are expected to experience coastal or riverine flooding or regular ocean water inundation in the short-term. Nine industrial buildings and 24 commercial/retail buildings are projected to experience coastal or riverine flooding in the short-term. Flooding of hotels, retail, and other commercial/industrial establishments could impact tourism and industry within the city.

- **Cultural Assets:** Two historic cultural assets (historic buildings) are projected to experience regular ocean inundation and wave run-up in the short-term. Flooding of cultural assets could cause water damage and impact access to the historic buildings.
- **Single Family and Multi-Family:** In the short-term, there are 119 single and multi-family residences with a high hazard-exposure grade. Of those, 35 multi-family units and 16 single-family homes are projected to experience regular ocean inundation in the short-term. The most at-risk multi-family and single-family residences are primarily clustered around the Buena Vista Creek and Oceanside Harbor, though there are susceptible housing units all along the Oceanside coast. An additional 172 mobile homes and 184 RV park sites are categorized as high-risk. All of the mobile homes and RV park sites projected to experience high exposure to hazards are located along the Loma Alta Creek. Riverine and coastal flooding of residential structures and RV park sites could cause water damage and temporarily disrupt access to the structures, while regular ocean inundation would result in total loss of the structure unless management actions are taken.
- **Shorelines and Preserves:** Beaches, bluffs, and preserve land is expected to be increasingly inundated and eroded over time. If shoreline armoring and development is maintained, beaches could be lost if no management actions (such as beach nourishment) are taken.
- **Critical Species Habitat:** Habitat for different coastal species, such as the Coastal California gnatcatcher, Least Bell's vireo, and Southwestern willow flycatcher, is expected to be increasingly inundated and eroded over time. How these species respond to changes in habitat are hard to predict, but it is likely that suitable habitat areas will decrease over time.
- **Wetlands:** While wetlands require some amount of inundation to function, increased erosion and flooding may change habitats and the species that can establish in those areas. For example, salt marsh vegetation species tend to establish at elevations dependent on inundation frequency. With sea-level rise, if certain plant species are inundated too frequently, they will drown out, and other plant species who can be exposed to more frequent inundation can establish. At some point, no species will be able to tolerate the increased inundation, and the wetlands will convert to mudflat and be lost if no management actions are taken.

These planning-level analyses and results are approximate and intended solely for the purpose of assessing potential future coastal vulnerabilities and informing the development of an Adaptation Plan and related LCP policies. Only assets identified through available geo-spatial data sets have been considered, so additional assets may need to be evaluated in the future.

In the next steps of the LCP preparation process, adaptation measures to reduce future vulnerabilities will be identified and assessed, and an Adaptation Plan will be developed. The Adaptation Plan will consider potential measures that include a range of accommodation, protection, and retreat strategies. Costs for no action and adaptive management strategies will be developed to provide more information and direction for the Adaptation Plan.

Section 7

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Section 8

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Appendix A

Existing Conditions

APPENDIX A
Existing Conditions and Related Studies

This appendix discusses the physical processes impacting coastal and riverine flooding in Oceanside. Note that the vertical datum used in this project is the North American Vertical Datum of 1988 (NAVD).

A.1 Coastal Flooding

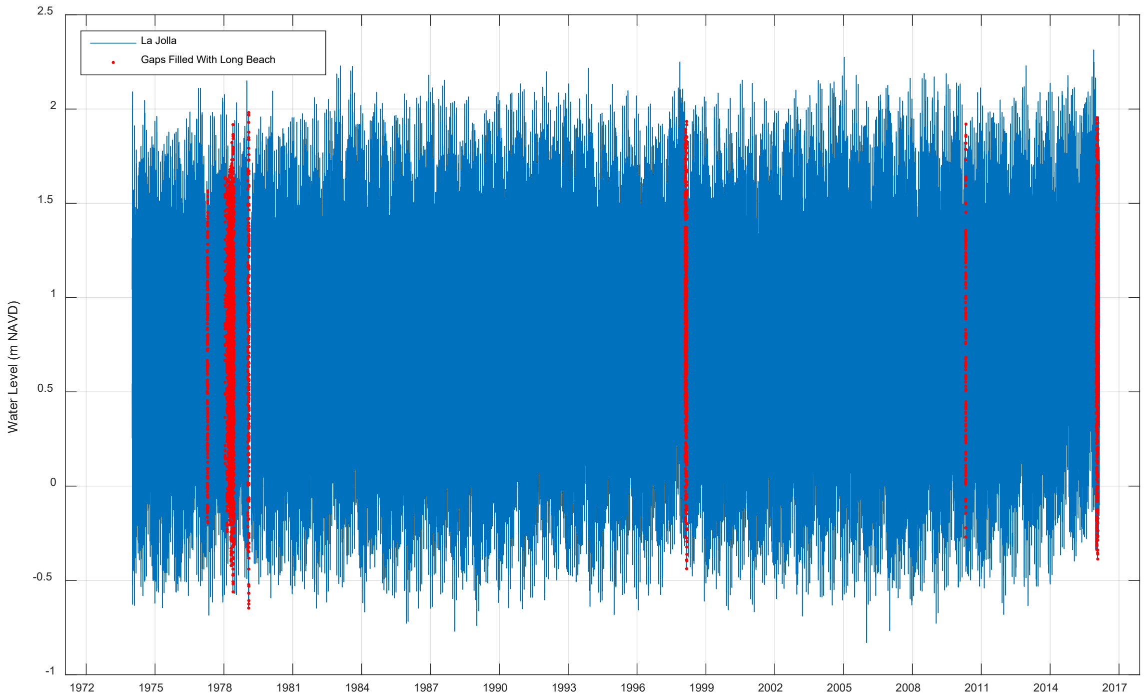
A.1.1 Tidal Water Levels

The San Diego coast experiences mixed semidiurnal tides, with two high and two low tides of unequal heights each day. In addition, the tides exhibit strong spring-neap tide variability; spring tides exhibit the greatest difference between high and low tides while neap tides show a smaller-than-average range. The spring-neap tides also vary on an annual cycle, with the highest spring tides occurring in June-July and December-January and the weakest neap tides occurring in March-April and September-October. Tidal datums for the La Jolla Scripps Pier tide gage (NOAA NOS#9410230), which is the closest gage to Oceanside with data since 1924, are summarized in **Table A-1** (NOAA Tides and Currents).

TABLE A-1
NOAA TIDAL DATUMS FOR THE LA JOLLA TIDE GAGE

Tidal Datum		ft MLLW	ft NAVD
Highest Astronomical Tide	HAT	7.14	6.95
Mean Higher High Water	MHHW	5.33	5.14
Mean High Water	MHW	4.60	4.41
Mean Tide Level	MTL	2.75	2.56
Mean Sea Level	MSL	2.73	2.54
National Geodetic Vertical Datum of 1929	NGVD	2.30	2.11
Mean Low Water	MLW	0.91	0.71
North American Vertical Datum of 1988	NAVD	0.19	0
Mean Lower Low Water	MLLW	0	-0.19

Figure A-1 shows the hourly tidal data from January 1974 to March 2016. The record at La Jolla contains several data gaps, some of which occurred during historical flood events in Southern California. Data from Los Angeles Outer Harbor in Long Beach (NOAA NOS#9410660) was used to fill these gaps (red in Figure A-1).



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SOURCE: NOAA Tides and Currents (NOS#9410660 and NOS#9410230)

Figure A-1
Water Level Record from La Jolla Gage (filled with Los Angeles/Long Beach Outer Harbor Data in red)

A.1.2 Extreme Event Flooding

A.1.2.1 Coastal Storm Inundation

Coastal flooding in Oceanside was assessed in April 2015 by FEMA as part of the update to coastal flood hazard areas and Federal Insurance Rate Maps (FIRMS) along the coast of California. FEMA maps flood zones and elevations for the 1% and 0.2% annual-chance-of-occurrence events (100- and 500-year storm events, **Figure A-2**, see Section A.2.1 for description of flood zones). The most recent coastal analysis of Oceanside for FEMA was completed in April 2015. The analysis used methods outlined in FEMA's 2005 Pacific Guidelines to evaluate five coastal hazards (wave setup and runup, storm surge still water elevation [SWEL], dune erosion, wave overtopping, and harbor analysis) and determine base flood elevations.

The wave setup and runup analysis incorporated 50-year hourly deepwater wave hindcast modeling by Oceanweather Inc. in 2009. Scripps Institute of Oceanography (SIO) and BakerAECOM used the SIO Shelf Model to transform the deepwater waves to nearshore waves along the coast (2014). Storm surge stillwater elevations were evaluated using historical tide gage records from 1960-2009 for NOAA's La Jolla (NOS #9410230) and San Diego (NOS #9410170) gages. Dune erosion, wave overtopping, and the harbor analysis were performed by Kriebel and Dean, Cox-Machemehl, Penney and Price, and Wiegel, following methods outlined in FEMA's 2005 Pacific Guidelines.

SOURCE: FEMA, USGS, City of Oceanside 2018, SanGIS 2018

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Figure A-2
FEMA and CoSMoS Flood Inundation Areas (Coastal Zone shown in orange)

FEMA's mapping along the Oceanside coast shows that base flood elevations, or anticipated flood water elevations during the 1% annual-chance flood event, range from 8-13 ft NAVD (Figure A-2). Overland wave propagation was modeled using FEMA's one-dimensional Pacific Wave Height Analysis for Flood Insurance Studies (PWHAFIS). WHAFIS modeling uses transects and their corresponding still water elevation, starting wave height, and wave period to compute the incident wave height.

Coastal flooding in Oceanside has also been assessed by the USGS through their Coastal Storm Modeling System (CoSMoS). CoSMoS evaluates the extent and depth of coastal flooding for four different storm scenarios (existing conditions, 100%-annual chance of occurrence, 5%-annual chance of occurrence, and 1%-annual chance of occurrence) under nine different sea-level rise scenarios (0 m sea-level rise [present day] to 2 m sea-level rise in 0.25 m increments, and 5.0 m sea-level rise). CoSMoS uses a three-tiered model that includes a global scale wave model and multiple regional/local models to compute currents, waves, tides, and morphodynamic change and flood hazards along the coast. The current 1%-annual chance of occurrence coastal flooding based on the CoSMoS approach is shown in Figure A-2**,** which also shows the FEMA flooding hazard for comparison.

A.1.2.2 Dam Inundation

Lake Henshaw, a 50,000 acre-feet capacity reservoir approximately 35 miles east of Oceanside, poses additional flooding risks to the community (San Diego County 2010). A Draft Dam Failure Map developed for the County of San Diego Hazard Mitigation Planning identified the Lake Henshaw Dam as a high-risk structure, and areas adjacent to the San Luis Rey River as high-risk zones subject to dam inundation for the entire stretch of the river within the Oceanside city limits. In the coastal zone, the hazard generally coincides with the 0.2% annual-chance event flood zone (**Figure A-3**). The Lake Henshaw dam inundation mapping was performed by the California Office of Emergency Services and represents a best estimate of inundation hazards using available techniques and inputs.

A.1.2.3 Tsunami Inundation

A tsunami is a series of waves generated in a body of water by a rapid disturbance (e.g., submarine seismic, volcanic, or landslide event) that vertically displaces water. Low-lying coastal areas are susceptible to inundation or flooding due to tsunami events. Tsunami hazard areas in Oceanside are shown in **Figure A-4**. Tsunamis can result from sources located relatively nearby or from very distant events. Relatively local earthquakes and landslides off the California, Oregon, and Washington coast pose the greatest threat of tsunamis that can reach California's coastline in less than an hour. While it is most common for tsunamis to be generated by subduction faults, such as those found in the Cascadia Subduction Zone or distant locations including Japan, tsunamis can also be generated from strike-slip faults (such as the small one that was triggered by the 1906 San Andreas earthquake).

SOURCE: City of Oceanside 2018

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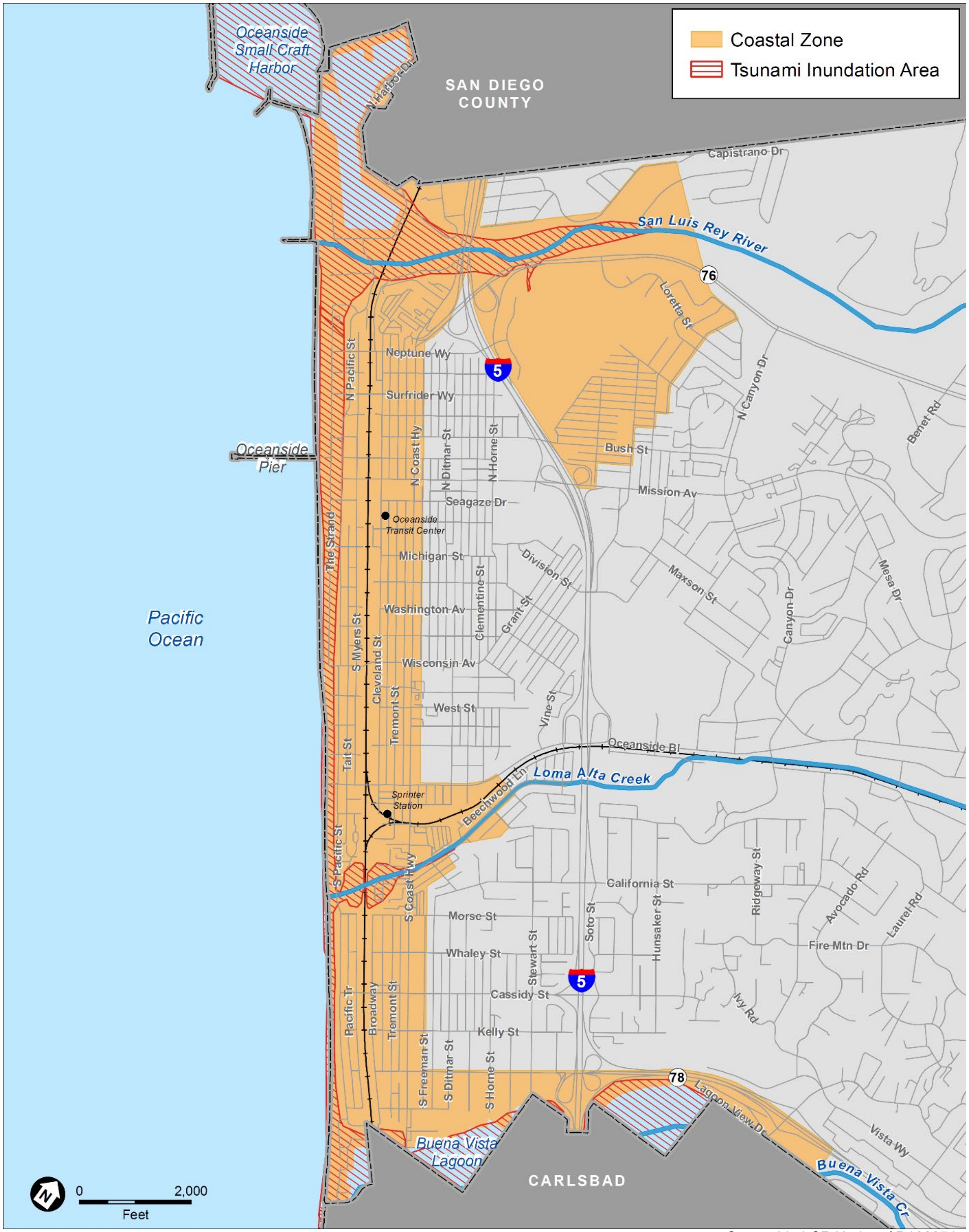
Figure A-3
Lake Henshaw Dam Inundation Area



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SOURCE: City of Oceanside 2018, SanGIS 2018, Cal EMA, CGS, USC

Figure A-4
Tsunami Inundation Area

Tsunami inundation mapping done by California Emergency Management Agency (CEMA, now the California Governor's Office of Emergency Services), the California Geological Survey (CGS), and the University of Southern California (USC) in 2009 shows potential flooding along the coast and adjacent to the San Luis Rey River, Loma Alta Creek Slough, and Buena Vista Creek and Lagoon (CEMA et al. 2009, Figure A-4). The joint mapping effort used a suite of local and distant source events to evaluate tsunami inundation (in Oceanside, the source events were earthquakes on the Carlsbad Thrust Fault, Catalina Fault, San Mateo Thrust Fault, and Central Aleutians Subduction Zone #1 and #3, and the 1964 Alaska Earthquake). Though the active Rose Canyon Fault lies approximately five miles offshore, its proximity to the Oceanside coast and physical structure indicate tsunami conditions are unlikely following an earthquake (City of Oceanside 2002).

A.2 River and Lagoon Flooding

As opposed to coastal flooding, where water from the ocean causes inundation of the land, river and lagoon flooding happens after precipitation events, when rainwater falling on a watershed is directed to a water way, which may then overtop into surrounding areas if it is not drained quickly enough. Lagoons add more complexity to the process as flows to the ocean can be constricted by sand berms at the mouth of the water way.

Figure A-2, above, shows the extent of flooding mapped by FEMA and CoSMoS during the 1%-annual chance event for the San Luis Rey River, Loma Alta Creek, and Buena Vista Creek, based on methods discussed in more detail below.

A.2.1 San Luis Rey River

The FEMA maps **(**Figure A-2) shows the land surrounding the San Luis Rey River as Zone "A99", which indicates that the area is subject to flooding from the 1% annual-chance event but which will ultimately be protected by a Federal flood protection system. The San Luis Rey River flood protection project, which will deepen the floodway through the removal of 210,000 cy of sediment along a mile stretch between Benet Road and Foussat Road, was authorized by congress in 1970 as part of the Flood Control Act of 1965 (USACE 2014) but has yet to be completed. No base flood elevations or depths are provided for Zones A99, because these areas typically do not have current modeling by FEMA which include the existing or future Federal project. FEMA also shows land adjacent to the San Luis Rey River within the 0.2% annual chance event zone (Figure A-2).

Modeling of the San Luis Rey River has occurred in pieces. A HEC-2 hydraulic analysis for the San Luis Rey River was performed by Nolte and Associates in August 1986. In 1990, Graves Engineering performed an updated hydraulic analysis for the reach from Interstate 15 to approximately Shearer Road. Cross-sections were obtained through digitized aerial surveys by Hugh Pugh and Associates in October 1983. Peak discharges were taken from an unpublished California Department of Water Resources document (DWR unpublished). At the mouth, the calculated 1% annual chance and 0.2% annual chance peak discharges are 51,000 and 120,000 cubic feet per second (cfs), respectively. Flood inundation mapping of the San Luis Rey River near the coast indicate inundation during a 1% annual chance storm event, but base flood elevations are not provided by FEMA.

A.2.2 Loma Alta Creek and Slough

The FEMA maps (Figure A-2) show the area surrounding the Loma Alta Creek and regulatory floodway within the 1% annual chance flood zone. The calculated base flood elevation varies from 14.3 feet NAVD at the estuary to 24.3 feet NAVD at the junction with I-5. Like the San Luis Rey River, portions of the adjacent land are mapped within the 0.2% annual chance flood zone.

The hydraulic and hydrologic analysis for the Loma Alta Creek was performed by George S. Nolte & Associates in July 1985. The coastal hydrologic analysis was performed by Dames & Moore. Peak discharges were calculated using guidance from San Diego County's Hydrology Manuel (October 1983). At the mouth, the 1% annual chance and 0.2% annual chance peak discharges are 3,800 and 8,200 cfs, respectively. A Location of Map Change (LOMC) was issued for the Loma Alta Creek in 2001 due to the construction of a bypass culvert and fill placement (2001). The preliminary FEMA Flood Insurance Study (issued February 2017) has incorporated an additional LOMC for Loma Alta Creek to reflect topographic changes occurring since 1997. The most recent LOMC is anticipated to alter the Loma Alta Creek and Slough within the coastal zone by narrowing the floodplain by approximately 500 feet at a point 800 feet downstream of I-5 (City of Oceanside 2018).

ESA previously developed a hydraulic model of the Loma Alta Slough based on the 1979 FEMA model and an updated survey of the slough bathymetry. Review of the model showed that water levels in Loma Alta Slough are driven by the state of the mouth of the slough; if the mouth is closed, the water levels back up and reach higher elevations than when the mouth is open. The FEMA river flood mapping for Loma Alta Slough is based on modeling that assumes that the mouth is closed, which is likely conservative for current conditions, because the mouth would scour during a 1% annual chance riverine flood event, and water levels could be lower than what was modeled.

A.2.3 Buena Vista Creek

The FEMA maps (Figure A-2) show the land surrounding the Buena Vista Lagoon and Creek as subject to flooding from a 1% annual chance event. There are also a number of parcels adjacent to the Buena Vista Creek that are subject to the 0.2% annual chance event.

The Buena Vista Creek analysis was done using HEC-2 by Dames & Moore and George Nolte and Associates between 1981 and 1986. Cross sections were digitized by the County of San Diego (1962-1983) and Harl Pugh and Associates (1983). Peak discharges were taken from a study by the San Diego County Department of Sanitation and Flood Control (1976). The 1% annual chance and 0.2% annual chance peak discharges for the Buena Vista Creek upstream of I-5 are 8,500 and 19,000 cfs, respectively.

Additionally, as part of the Buena Vista Lagoon Enhancement Project Environmental Impact Report (EIR), Everest International Consultants modeled river flooding for a 1% annual chance riverine storm event in the Buena Vista Lagoon. Results from the modeling included water levels for each basin under each scenario.

A.3 Coastal Armoring

An inventory of shore parallel armoring structures was developed in 2005 by NOAA Coastal Management Fellow Jennifer Dare for the entire California coastline by splicing a shoreline at armoring locations. In 2012, California Coastal Commission staff worked with ESA PWA staff (now ESA) to refine Jennifer Dare's shapefile into a comprehensive coastal armoring geodatabase that captures key attributes to better assist with coastal hazards planning and management. The data coverage in Oceanside still consists of the historic shoreline, and has not been updated since 2005. The database does not detail the specific type of shore parallel armoring, however conversation with City officials indicate that seawalls are the primary shoreline protection structures between the northern city limits and Tyson Street Park, at which point shoreline protections transitions to rip rap (Russ Cunningham, pers. comm. 2018). **Figure A-5** shows the coastal protective devices at Oceanside.

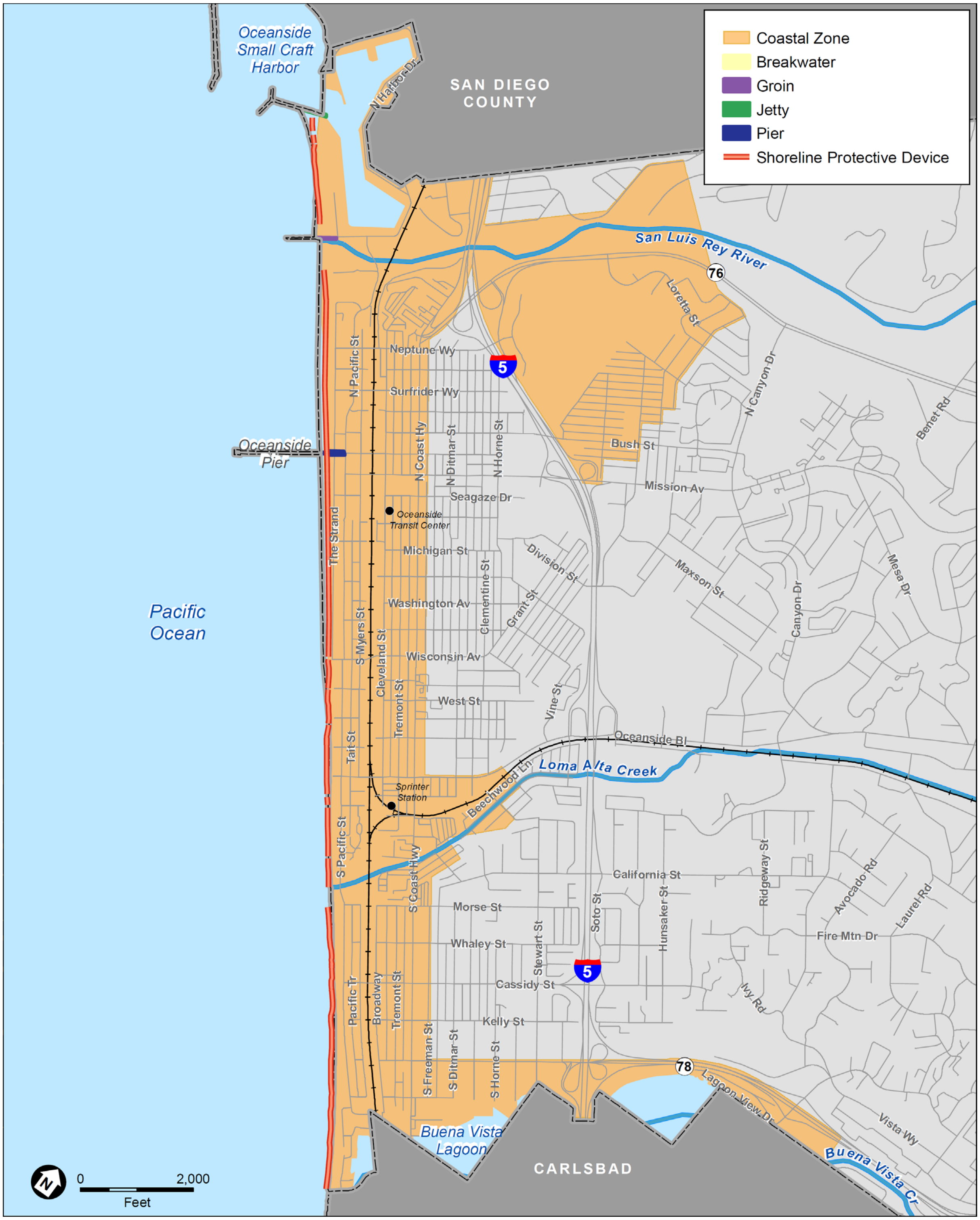
Other coastal structures in Oceanside include the San Luis Rey River groins, levees and floodwalls and the Oceanside Harbor jetties and breakwaters. The current-day Oceanside Harbor jetty was constructed in the early 1940s in front of the Camp Pendleton Boat Basin. In the early 1960s, the breakwater was extended to protect the newly constructed Oceanside Harbor. Both the jetty and harbor have significantly impacted littoral sand transport (see Section A.4); USACE estimates the harbor and breakwater have caused the loss of 1.4-1.6 million cy of sand on Oceanside beaches between 1942-2016 (Sifuentes 2016). Section A.4.4 details the harbor maintenance dredging and associated beach nourishment plan.

A.4 Coastal Sediment Processes

An understanding of existing deposition, erosion, and sediment transport patterns in the Oceanside Littoral Cell (OLC), which spans approximately 57 miles from Dana Point to Point La Jolla, is pertinent to determining how sea-level rise may impact Oceanside's beaches and riverine systems. This section covers the existing processes that impact the beach and rivers/lagoons.

A.4.1 Longshore Transport

Longshore transport is the movement of sand along the coastline by waves. Many studies have been conducted to quantify this movement in the OLC as shown in Table A-2. Typically, summer waves produce northerly transport, but winter waves, which have more energy, produce transport to the south. In general, studies have found that the sand predominantly moves downcoast (south) through the OLC (USACE 1991). However, changes in wave direction occasionally result in upcoast sediment transport.



SOURCE: City of Oceanside 2018, SanGIS 2018, NOAA 2005t

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Figure A-5
Coastal Armoring and Structures

USACE (1991) reviewed previous studies of potential longshore transport near Oceanside and found approximately 740,000 cubic yards (cy) of sediment moving to the south annually, and 546,000 cy moving to the north. This results in a potential gross transport (i.e., the sum of movement north and south) of 1,286,000 cy/yr and a potential net transport (i.e., the difference between movement north and south) of 194,000 cy/yr to the south.

Moffatt and Nichol (as well as Inman and Masters 1991) analyzed net transport rates during different time periods. Both studies found a decrease in longshore transport to 40,000 – 50,000 cy/yr to the south in the 1980s when compared to previous decades. These studies suggest this decrease was related to a more variable wave climate between 1980 and 1990, which increased wave activity from the south, increasing transport to the north, and thus decreasing net transport to the south (USACE 2015). **Table A-2**, below shows the additional longshore transport estimates in the OLC.

A.4.2 Cross-Shore Transport

Cross-shore transport is the movement of sand, driven by waves, between onshore and offshore. When sand is driven onshore, it can build up beach berms. Sand driven offshore can end up in an offshore bar, where it can be later moved back to the beach, or be lost from the system offshore or to a submarine canyon. This process is also seasonal and in the winter, storm events erode the shoreline and move sand offshore. Some of the sand is moved south by bottom currents and lost to the La Jolla submarine canyons. In the summer, sand that has not been lost is then pushed back onto the beach by the waves.

Moffatt and Nichol (1990) used offshore surveys to quantify the cross-shore transport in the OLC. They found approximately 260,000 cy/yr net cross-shore transport for the entire littoral cell, with an average of 1 cy/yr per foot of shoreline. For Oceanside, this represents a loss of approximately 19,600 cy/yr of sand based on the shoreline length. This value can be thought of as a “loss” of a little less than one foot of beach width per year, or two feet of beach width every two years, on average.

A.4.3 Bluff/Gully/Terrace Erosion

Where coastal armoring is not present, erosion of sand and gravel from the bluffs will contribute material to the beach. A study conducted by the California Department of Boating and Waterways (CDBW) and the State Coastal Conservancy (SCC) in 2002 determined that roughly 55,000 cy of sand is contributed to the OLC annually from eroding bluffs. The study also calculated that an additional 12,400 cy/yr of material does not make it to the beach due to coastal armoring (see Section A.3 for more details on coastal armoring).

In 2006, Young and Ashford conducted a more site-specific evaluation of bluff contributions for the OLC and found the bluffs were contributing 100,000 cy of sand annually. Their study looked specifically at the bluffs between the Santa Margarita River and the Bataquitos Lagoon and found erosion rates of 0.11 ft/yr, contributing roughly 4,000 cy of sand annually.

TABLE A-2
POTENTIAL LONGSHORE SEDIMENT TRANSPORT ESTIMATES

Source		Transport to South (cy/yr)	Transport to North (cy/yr)	Gross Transport (cy/yr)	Net Transport (cy/yr)	Method/Source
Marine Advisers	1960	760,000	545,000	1,305,000	216,000 To South	Wave energy flux method near Oceanside (in USACE 1991)
Hales	1978	643,000	540,000	1,183,000	102,000 To South	Wave energy flux method near Oceanside
Inman and Jenkins	1983	807,000	553,000	1,360,000	254,000 To South	Wave energy flux method near Oceanside (in USACE 1991)
Tekmarine, Inc.	1987	520,000	414,000	934,000	106,000 To South	South of Oceanside harbor (in USACE 1991)
Patsch and Griggs	2006				146,000 To South	Based on dredging at Oceanside harbor

While Oceanside's bluffs are mostly set back behind a line of development, there are a series of bluffs between Mission and Tyson street that are exposed. Multiple studies have evaluated bluff erosion and retreat along the coast of California and specifically within the vicinity of Oceanside, including Everts (1991), Hapke and Reid (2007), and Young (2017). Cliff retreat rates for these individual studies are further discussed below and summarized in **Table A-3**.

TABLE A-3
CLIFF RETREAT RATES IN THE LITERATURE

Study	Location	Cliff Dates	Cliff Top Retreat (ft/yr)		
			Minimum	Mean	Maximum
Everts, 1991	Oceanside Littoral Cell	1954-1988		0.07 - 0.49	
Hapke and Reid, 2007	Oceanside, CA	1934-1998	0.26	0.66	1.15
Young, 2017	San Diego County	1930s-1998		0.39	13.8
		1998-2010		0.46	13.8

Source: Everts (1991), Hapke and Reid (2007), Young (2017)

Everts (1991) found average sea-cliff erosion rates within the OLC between 0.07-0.49 ft/year based on an empirical method that uses wave energy, erosional resistance, and beach width.

As part of the USGS's National Assessment of Shoreline Change, Hapke and Reid (2007) evaluated cliff retreat in the OLC by comparing historical cliff edges (based on NOAA's NOS topographic sheets [T-Sheets] from 1933/1934) with recent cliff edges derived from airborne LIDAR data from 2002. Hapke and Reid found an average retreat rate of 0.66 ft/yr, which is higher than the results from Everts 1991.

Young (2017) used similar methodology as the USGS study to measure coastal cliff erosion and retreat spanning the California coast from Bodega Head, California to the Mexico/United States border. Using airborne LIDAR data, Young evaluated recent cliff erosion by comparing the 1998 cliff edge previously delineated by Hapke and Reid (2007) to a newly-delineated cliff edge derived from LIDAR flown in 2009/2010. In San Diego County, Young found a mean recent cliff top retreat of 0.46 ft/yr.

A.4.4 Beach Nourishment

Beach nourishment involves placing additional sand on a beach to raise the shoreline profile, which, in turn, extends the beach farther seaward, creating a wider beach. Sand has been placed on beaches in the OLC for many years through multiple means. Sand bypassing at the Harbor, which involves removing sand from within the harbor and placing it on the downshore beach, has occurred either annually or biennially since construction of the harbor began in 1961. SANDAG has led the Regional Beach Sand Project (RBSP) with two placements in 2001 and 2012. Additionally, opportunistic sand placements occurred in the 1970s and 1980s when sand has become available through other projects beyond routine harbor dredging, noted in Table A-4 below. These three means of sand nourishment are discussed below.

A.4.4.1 Harbor Sand Bypassing

The Oceanside Harbor is a federal navigation channel, which requires inlet maintenance per the 1944 Flood Control Act and 1946 Rivers and Harbor Act. Per the federal Oceanside Harbor Maintenance Dredging Plan, USACE is responsible for the annual dredging of the Entrance Channel, Oceanside Channel, and Del Mar Channel to design depths (-25 ft MLLW for the entrance channel and -20 ft MLLW for the Oceanside and Del Mar Channels, **Figure A-6)**. Until 2010, the dredged sediment was primarily placed south of the Oceanside Pier beginning at Tyson Street (Joe Ryan, pers.comm., 2017). Since 2010, dredged material has been placed in areas with decreasing beach widths, notably the stretch between the San Luis Rey River and Tyson Street, in front of the Lifeguard Headquarters at the Oceanside Pier, the North Coast Village, and nearshore at Forster Street (Ryan, pers.comm., 2017). If excess dredged material remains following placement at priority locations, additional beach nourishment begins at the Oceanside Pier and continues southward.

Annual dredge volumes vary but average between 180,000-200,000 cy (Ryan, pers.comm., 2017). Dredging and beach nourishment typically occur during the spring. The City of Oceanside maintains harbor dredge and beach nourishment records beginning in 1942 and has beach fill reports beginning in 2008. **Table A-4** below shows the Oceanside Harbor dredge and nourishment history.

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SOURCE: City of Oceanside 2018t

Figure A-6
USACE Harbor Maintenance Dredging Locations

TABLE A-4
OCEANSIDE HARBOR DREDGE AND NOURISHMENT HISTORY

Year	Dredge Volume (y3)	Disposal Location
1945	219,736	Upland
1960	40,546	Oceanside Beach, 6th Street to 9th Street
1961	481,326	Oceanside Beach, 6th to 9th street
1965	111,176	Oceanside Beach, 3rd Street to 9th Street
1966	684,058	Oceanside Beach, 3rd street to Wisconsin
1967	177,881	Oceanside Beach, 3rd Street to Tyson
1968	434,239	San Luis Rey River to Wisconsin Street
1969	353,147	San Luis Rey River to 3rd Street
1971	551,955	Oceanside Beach, 3rd Street to Wisconsin
1973	344,500[1]	Oceanside Beach, Tyson to Wisconsin
1975	506,177	Oceanside Beach, Tyson to Witherby
1976	460,398	Oceanside Beach, Tyson to Witherby
1978	306,060	Oceanside Beach to Witherby
1981	863,247	Oceanside Beach, Seagaze Drive to San Malo
1982	919,489[1]	Oceanside Beach, 1st street to Oceanside Boulevard
1984	405,465	Oceanside Beach
1986	393,693	Tyson Street to Wisconsin Street
1988	219,736	Oceanside Beach
1990	249,818	Oceanside Beach
1992	188,345	Tyson Street
1994	482,634	2nd Street to Wisconsin Street
1995	160,878	Nearshore at Forster Street
1996	162,186	Nearshore at Forster Street
1997	128,179	Nearshore at Forster Street
1998	315,216	Nearshore at Forster Street
1999	172,649	Tyson Street
2000	281,209	Tyson Street
2001	79,785	Tyson Street
2002	400,000	Oceanside Beach
2003	438,000	Oceanside Beach
2004	222,000	Oceanside Beach
2005	262,000	Oceanside Beach
2006	228,000	Oceanside Beach
2007	72,000	Nearshore
2007	122,000	Oceanside Beach
2009	187,300	Oceanside Beach
2010	269,000	Oceanside Beach
2011	180,000	Oceanside Beach
2012	244,000	Oceanside Beach

TABLE A-4
OCEANSIDE HARBOR DREDGE AND NOURISHMENT HISTORY

Year	Dredge Volume (y3)	Disposal Location
2013	193,800	Oceanside Beach
2014	275,000	Oceanside Beach
2015	199,400	Oceanside Beach
2016	245,000	Oceanside Beach
2017	435,000	Oceanside Beach

NOTES: [1] Indicates Opportunistic Placement (Sand not derived from Harbor)
Prior to 2010, beach placement occurred South of Tyson street. Since 2010, placement has been at the North Coast Village and the Oceanside Pier.

SOURCE: USACE and Ryan 2017

A.4.4.2 Regional Beach Sand Project

In addition to dredging and nourishment performed at Oceanside Harbor, SANDAG has completed two regional sand placements with placements in Oceanside. RBSP I occurred from the beginning of April to the end of September in 2001, and placed 2.1 million cy of beach sand on twelve receiver beaches between Oceanside and Imperial Beach (**Table A-5**). Approximately 421,000 cubic yards of sand was placed in Oceanside in 2001 as part of the RBSP I project. In 2012, SANDAG implemented RBSP II, which built upon the efforts of the RBSP I. From September to December 2012, RBSP II placed 1.5 million cy of sand on eight of the previous receiver beaches (Table A-5). Oceanside received 293,000 cubic yards of sand in 2012 as part of the RBSP II project.

A.4.5 Beach Dynamics

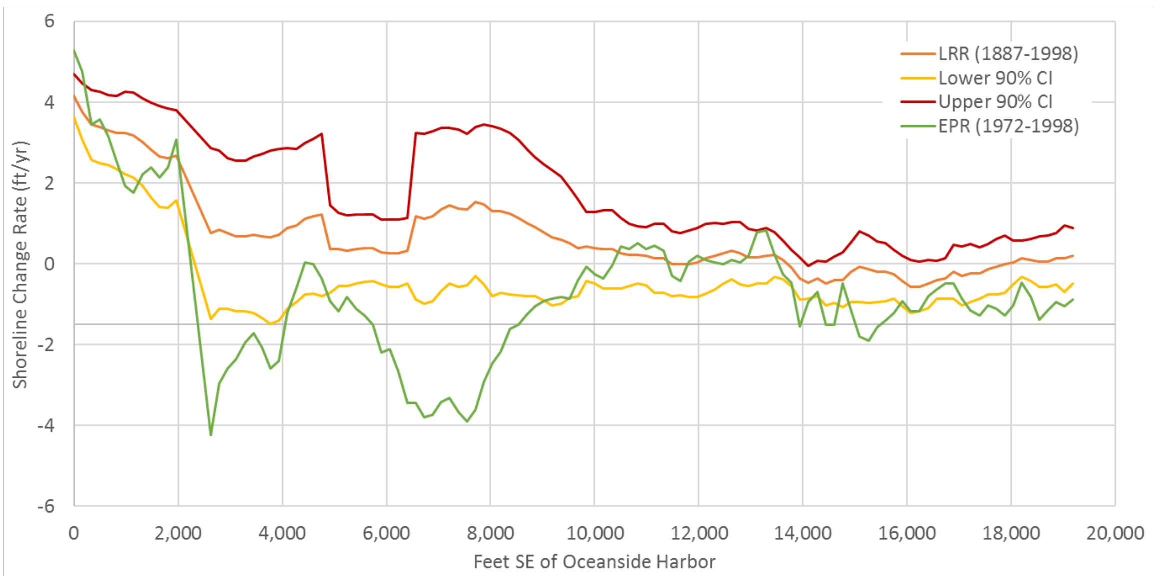
A substantial volume of data has been collected analyzing the dynamics of the beaches in the OLC. The USGS has analyzed shoreline changes over time and SANDAG has been collecting beach cross-sections, or profiles, since 1997, conducting both spring and fall surveys to capture the seasonal variation. Additionally, SANDAG calculates beach volume for each transect.

A.4.5.1 Shoreline Change

Figure A-7 shows historic shoreline change documented by the USGS (Hapke and Reid 2006) for the Oceanside coastline. Using four historic shorelines, USGS calculated long-term linear regression rates (LRR) of shoreline position at 50-meter spaced transects which are shown along with the 90% confidence interval (CI) for change rates at each transect. The LRR shows the rate between 1887 and 1998. USGS also calculated end point rates (EPR) of shoreline change from 1972 to 1998, the two most recent shorelines used in the study. Figure A-7 shows that since 1887, the beach has been growing just south of the Harbor and is relatively stable to around 14,000 ft (at approximately the Loma Alta Creek and Slough) where the beach has shown some erosion over time. More recently since 1972, the beach has shown more erosion (up to 4 ft/yr).

TABLE A-5
RBSP SAND PLACEMENT WITHIN THE OCEANSIDE LITTORAL CELL

	RBSP I (2001)		RBSP II (2012)	
Location	**Volume (cy)**	**Median Grain Size (mm)**	**Volume (cy)**	**Median Grain Size (mm)**
Oceanside	421,000	0.62	293,000	0.54
North Carlsbad	225,000	0.14 – 0.62	219,000	0.57
South Carlsbad	158,000	0.62	141,000	0.66
Bataquitos	117,000	0.62	106,000	0.59
Leucadia	132,000	0.62	n/a	n/a
Encinitas- Moonlight Beach	105,000	0.34 – 0.62	92,000	0.48
Encinitas- Cardiff State Beach	101,000	0.34	89,000	0.57
Solana Beach- Fletcher Cove	146,000	0.14	142,000	0.55
Del Mar	183,000	0.14	n/a	n/a
Torrey Pines	245,000	0.14	n/a	n/a

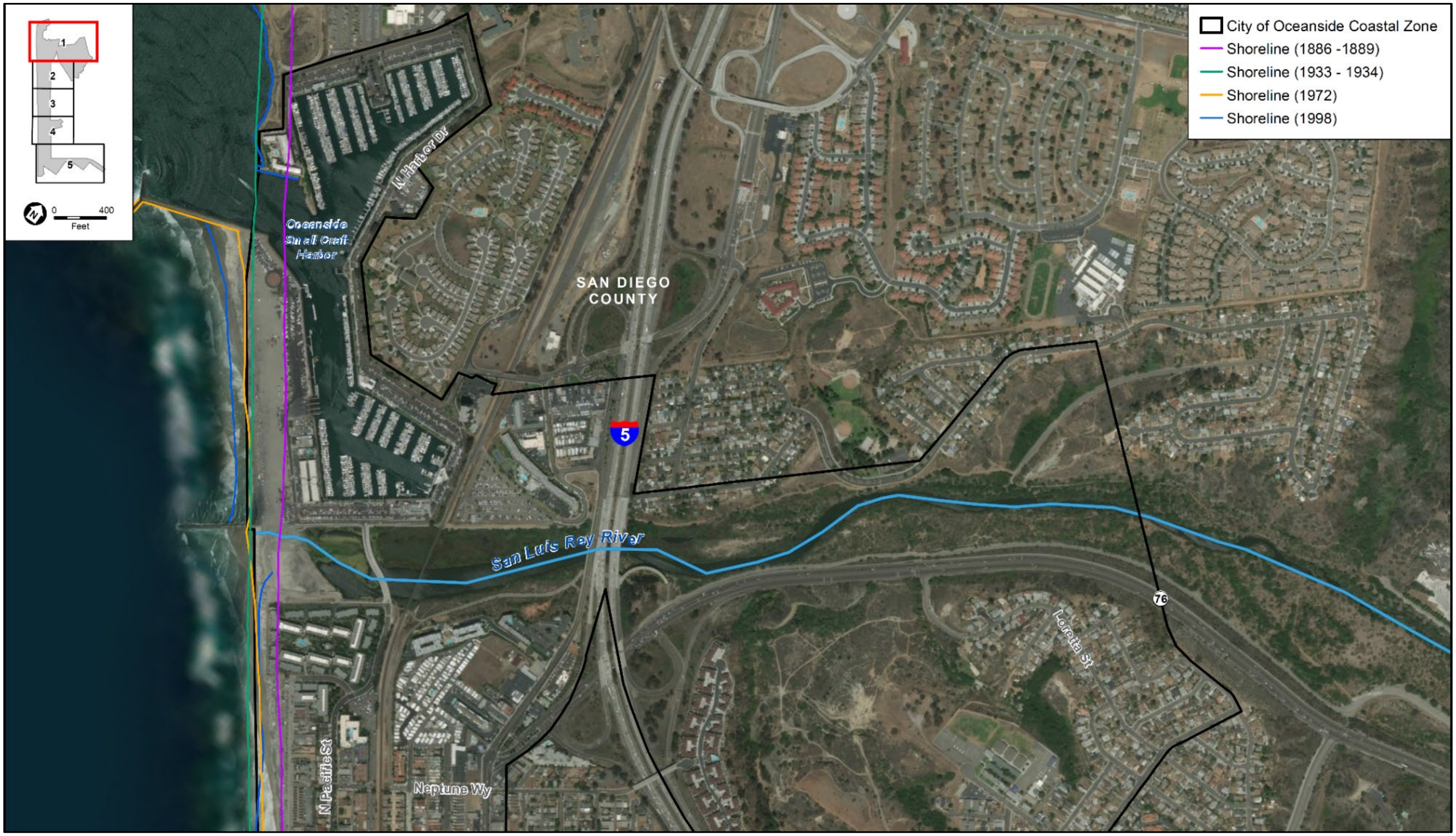


Oceanside LCP Update / D160871

SOURCE: Hapke and Reid 2006

Figure A-7
USGS Historic shoreline change in Oceanside

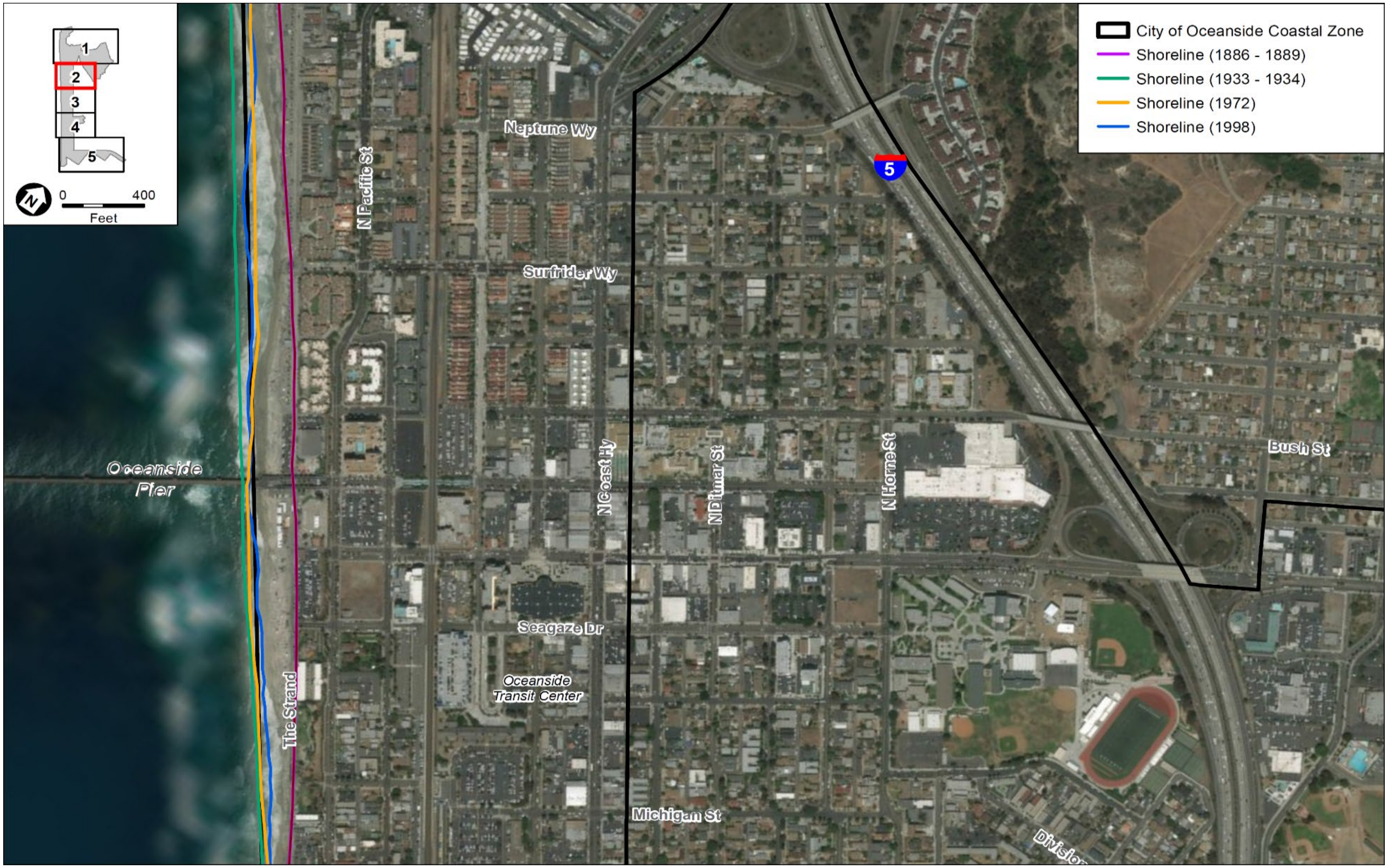
Figure A-8 through **Figure A-12** shows the historical shoreline position for four periods (1886-1889, 1933-1934, 1972, and 1998). In general, the figures indicate that beach width increased from 1886-1889 to 1933-1934 period, most notably from south of the Oceanside Harbor to approximately Seagaze Drive (Figure A-9). The 1933-1934, 1972, and 1998 positions show erosion in some locations and accretion in others as seen in Figures A-8 to A-12.



SOURCE: City of Oceanside, USGS 2006

Oceanside LCP Update / D160871

Figure A-8
USGS Historical Shorelines



Oceanside LCP Update / D160871

SOURCE: City of Oceanside, USGS 2006

Figure A-9
USGS Historical Shoreline

SOURCE: City of Oceanside, USGS 2006

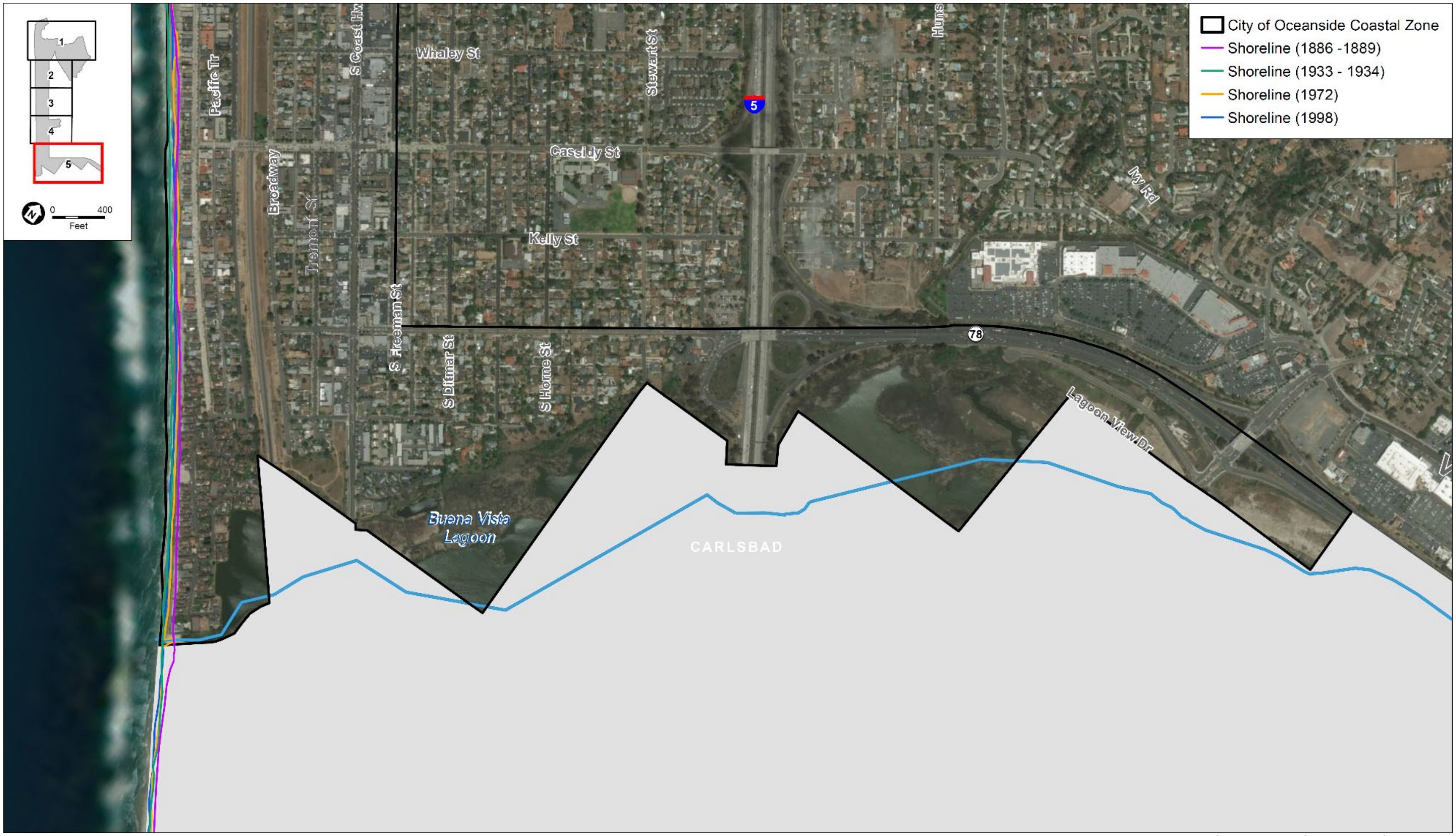
Oceanside LCP Update / D160871

Figure A-10
USGS Historical Shoreline

SOURCE: City of Oceanside, USGS 2006

Oceanside LCP Update / D160871

Figure A-11
USGS Historical Shoreline



Oceanside LCP Update / D160871

SOURCE: City of Oceanside, USGS 2006

Figure A-12
USGS Historical Shoreline

A.4.5.2 Beach Profiles and Volumes

Figure A-13 presents the SANDAG cross-sections within the study area. SANDAG cross-sections extend from defined points on the backshore (typically at the base of a seawall or other structure) out to depths of approximately -40 to -60 feet below mean lower low water (MLLW).

For each cross-section, SANDAG calculates the volume of sand at that location. In general, a larger volume of sand indicates a wider beach. **Figures A-14** and **A-15** show the total beach volumes (volumes above and below water) for the Oceanside cross-sections. In addition to the beach volumes, which were calculated from the cross-sections, nourishment volumes are also displayed.

A.5 Related Sea-Level Rise Studies

Two studies in the vicinity of Oceanside have already looked at sea-level rise and provide information for the Oceanside Vulnerability Assessment and Adaptation Plan.

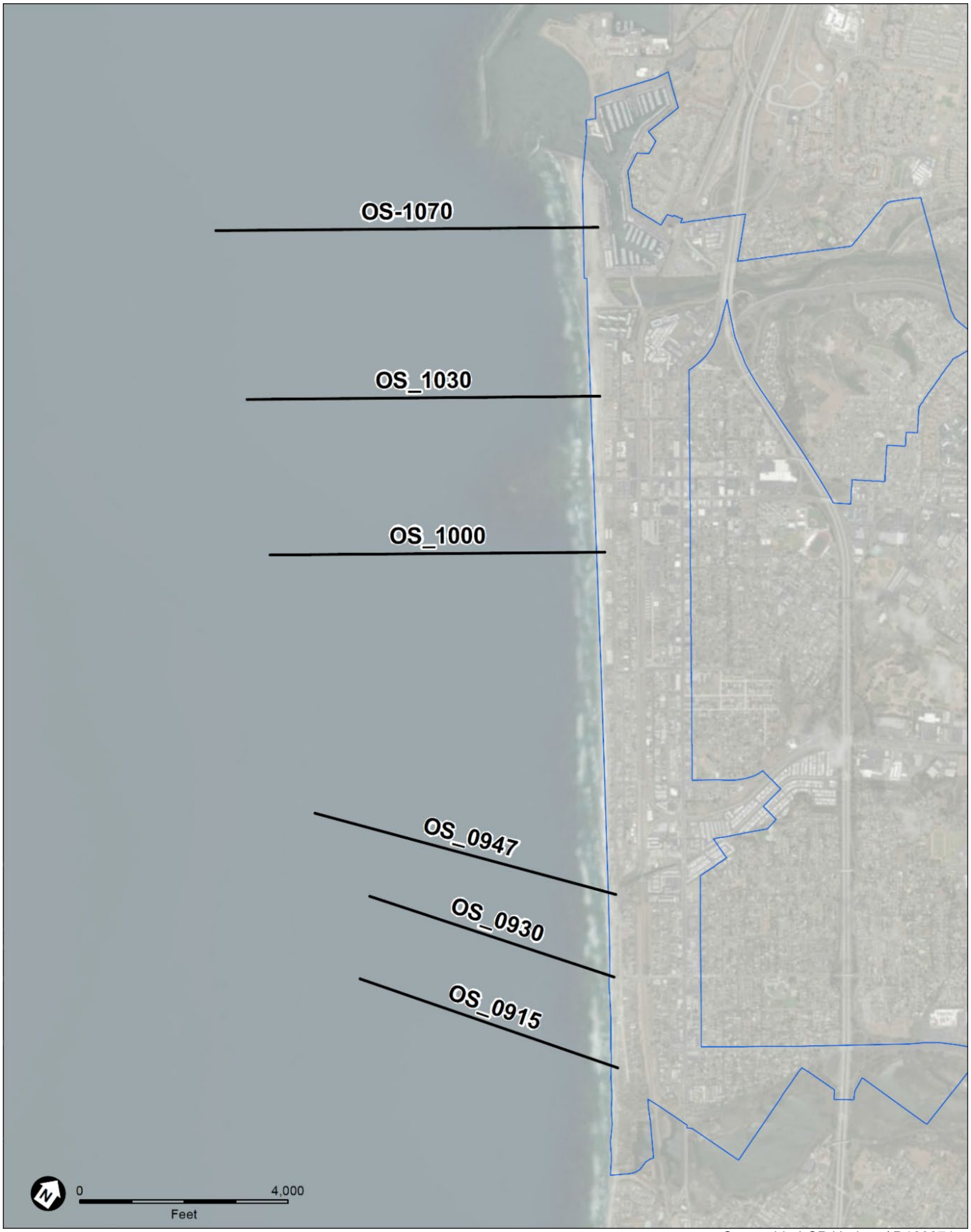
Young et al. (2014) developed a sand balance coastal profile model (Conditionally Decoupled Profile Model Framework, CDPM) to evaluate cliff and shoreline retreat along a 21 km stretch of coast within the Marine Corps Base Camp Pendleton (MCBCP), adjacent to the City of Oceanside to the north. The coastal recession model evaluates sand availability from gully erosion, subaerial cliff erosion, and external long-term sand supply/deficit to create a new beach and cliff profile. The CDPM model evaluated four different sea-level rise scenarios (0.5, 1.0, 1.5, and 2.0 m by 2100) and two sand budget scenarios (zero deficit and deficit). Key findings of the study include a mean retreat rate of 487 m and a maximum retreat rate of 21-179 m over a 100-year period, depending on the sea-level rise and sand budget scenarios. **Table A-6** below further summarizes the CDPM results.

TABLE A-6
CDPM CLIFF EROSION RETREAT RATES FOR MCBCP

SLR (m)	Sand Budget	Min (m)	Mean (m)	Max (m)
0.5	Deficit	7	62	131
	Zero Deficit	2	4	21
	Surplus	1	4	21
1.0	Deficit	7	70	148
	Zero Deficit	2	6	22
	Surplus	2	5	21
1.5	Deficit	21	79	163
	Zero Deficit	2	9	35
	Surplus	2	8	32
2.0	Deficit	37	87	179
	Zero Deficit	2	16	54
	Surplus	2	15	50

NOTE: Surplus sand budget comes from SPAWAR

Source: Young (2014) and SPAWAR (2014)



SOURCE: SANDAG

Oceanside LCP Update / D160871

Figure A-13
SANDAG Monitoring Profile Locations (Locations Approximate)

SOURCE: SANDAG 2016

Oceanside LCP Update / D160871

Figure A-14
SANDAG Beach Volumes (North)

SOURCE:SANDAG 2016

Oceanside LCP Update / D160871

Figure A-15
SANDAG Beach Volumes (South)

SPAWAR (2014) also employed the CDPM model as part of its analysis on the impacts of sea-level rise on military installments in the Southwestern United States. SPAWAR also included a sand surplus scenario; results of this additional analysis are included in Table A-6.

In general, the CDPM found higher retreat rates associated with shorter cliffs, which was attributed to less sand available for beach replenishment, thereby increasing the retreat required to balance the sand deficit.

Though Oceanside has intermittent bluffs that run from approximately Breakwater Boulevard to St. Malo, the shoreline is mostly developed with residential homes and business seaward of the bluffs, and not subject to many of the wave-related processes that facilitate cliff erosion. However, there are a series of exposed bluffs (most notable between Mission and Tyson Street) that will be subject to sea-level rise; the above studies can help inform potential future cliff retreat.

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Appendix B

Asset Data Sources

Appendix B- Asset Data Sources

Source	Asset Category	Asset	Type
CA Energy Commission	Energy	Transmission Lines	Line
CA Energy Commission	Energy	Natural Gas Pipelines	Line
CA Coastal Commission	Coastal Structures	Shoreline Protection	Line
USACE	Coastal Structures	Levee	Line
USACE	Coastal Structures	Floodwalls	Line
SanGIS	Buildings	Child care facilities	Point
ESA	Cultural	Cultural Resources	Point
SanGIS	Emergency Response	Fire stations	Point
SanGIS	Emergency Response	Police Stations	Point
SanGIS	Emergency Response	Lifeguard Headquarters	Point
SanGIS	Hazardous Materials	Gas stations	Point
SanGIS	Buildings	Commerical retail/Offices	Point
SanGIS	Buildings	Library	Point
SanGIS	Buildings	Colleges	Point
SanGIS	Buildings	School	Point
ICLEI	Stormwater	Storm cleanout	Point
ICLEI	Stormwater	Storm inlet	Point
ICLEI	Stormwater	Storm node	Point
ICLEI	Stormwater	Storm drain outfall	Point
ICLEI	Communications	Communication towers	Point
ICLEI	Wastewater	Sewer control valve	Point
ICLEI	Wastewater	Sewer fitting	Point
ICLEI	Wastewater	Sewer manhole	Point
ICLEI	Wastewater	Sewer structure	Point
ICLEI	Wastewater	Sewer system valve	Point
City of Oceanside	Wastewater	Wastewater pump stations	Point
ICLEI	Water	Fire hydrant	Point
ICLEI	Water	Fire protection	Point
ICLEI	Water	Water Fitting	Point
ICLEI	Water	Water Meter	Point
ICLEI	Water	System valve	Point
ICLEI	Water	Wells	Point
ICLEI	Water	Water pump station	Point
IRWM	Water	Water Treatment Plant	Point
IRWM	Water	Wastewater Treatment Plant	Point
City of Oceanside	Public Access and Recreation	Beach Access Locations	Point
SanGIS	Buildings	Religious Facilities	Polygon
SanGIS	Buildings	Mobile Home Park	Polygon
SanGIS	Buildings	Hotel/Motel	Polygon
SanGIS	Cultural Resources	Cemetery	Polygon
City of Oceanside	Buildings	Land Use	Polygon
City of Oceanside	Buildings	Bldg Footprint	Polygon
SanGIS	Natural	Wetlands	Polygon
USFWS	Natural	Critical Habitat	Polygon
SanGIS	Public Access and Recreation	Parks	Polygon
ESA	Natural	Coastal Bluffs	Polygon
USACE	Coastal Structures	Coastal Structures	Polygon
City of Oceanside	Transportation	Roads	Polygon
City of Oceanside	Coastal Structures	Levee	Polygon
SanGIS	Natural	Beaches	Polygon
City of Oceanside	Public Access and Recreation	Bicycle Routes	Polyline
SanGIS	Public Access and Recreation	Trails	Polyline
ICLEI	Stormwater	Storm drain	Polyline
City of Oceanside	Transportation	Roads	Polyline
City of Oceanside	Transportation	Railroads	Polyline
ICLEI	Wastewater	Sewer lateral	Polyline
ICLEI	Wastewater	Wastewater outfall	Polyline
City of Oceanside	Wastewater	Wastewater distribution pipelines	Polyline
City of Oceanside	Water	Water distribution pipelines	Polyline
ICLEI	Water	Water service	Polyline
EnviroStor	Hazardous Materials	LUST Sites	Point

Appendix C

Exposure Tables

Table C1: Exposure to Hazards
Point Assets

Unit = Count	Current Conditions				Short-Term					Mid-Term					Long-Term					2100 and Beyond				
Point Asset Description	Current Ocean Water Levels	Current Coastal Flooding and Waves	Current Coastal and Riverine Flooding	Current Flooding with Wave Runup	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and Riverine Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and Riverine Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and Riverine Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and Riverine Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion
Beach Access Locations	0	3	1	13	3	2	0	14	0	3	3	1	8	1	3	5	1	12	19	8	4	0	12	23
Cultural Resources	0	1	0	1	1	0	0	1	0	1	0	0	1	0	1	0	0	1	2	2	1	0	0	3
Fire Hydrant	0	5	32	2	14	2	26	5	0	24	4	21	5	0	36	4	9	13	9	48	3	5	9	29
Water Fitting	7	3	48	2	32	4	25	6	0	39	6	19	7	0	51	2	12	11	4	57	4	8	8	27
Gas Stations	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Hazardous Material LUST Sites	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0
Lifeguard Headquarters	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1
Pump Station	0	1	6	0	2	1	4	0	0	2	1	5	1	0	4	1	5	1	0	7	1	3	1	2
Water Meter	1	5	139	14	54	9	99	21	0	77	13	87	25	0	109	17	43	58	16	156	7	18	51	265
Sewer Control Valve	0	0	2	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	1	0	0	2
Sewer Fitting	0	0	4	1	2	0	3	1	1	3	0	6	3	1	7	0	4	3	1	11	0	2	1	4
Sewer Manhole	0	12	67	14	28	9	49	24	0	32	13	53	28	1	45	13	40	33	30	68	12	29	26	71
Sewer Structure	0	1	6	0	2	1	4	0	0	2	1	5	1	0	4	1	5	1	0	7	1	3	1	2
Storm Cleanout	0	5	19	4	14	4	8	2	0	15	6	7	2	2	19	4	6	2	9	23	2	6	0	20
Storm Inlet	2	11	124	13	75	8	67	18	0	90	12	65	19	2	126	9	47	24	34	150	12	37	11	66
Storm Node	0	3	14	0	5	2	11	1	0	7	2	9	1	0	7	2	10	1	3	10	0	8	1	13
Storm Outlet	44	11	63	15	71	8	40	13	7	72	10	39	8	11	80	8	37	8	23	101	0	30	2	28
System Valve	1	10	104	5	54	6	64	13	0	72	12	55	19	0	102	10	32	29	15	127	11	16	21	78
Well	0	0	3	0	2	0	1	0	0	2	0	1	0	0	2	0	1	0	0	2	0	1	0	0

Table C2: Exposure to Hazards
Line Assets

Unit = Miles	Current Conditions				Short-Term					Mid-Term					Long-Term					2100 and Beyond				
Line Asset Description	Current Ocean Water Levels	Current Coastal Flooding and Waves	Current Coastal and River Flooding	Current Flooding with Wave Runup	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion
Bicycle Routes	0.0	0.2	2.7	0.1	0.9	0.3	1.9	0.1	0.0	1.2	0.3	1.8	0.1	0.0	1.6	0.3	1.5	0.1	0.0	2.2	0.1	1.3	0.1	1.2
Roads	0.0	0.3	6.6	1.0	1.4	0.2	5.8	1.1	0.0	1.9	0.5	5.6	0.9	0.2	2.7	0.5	5.0	1.0	1.4	3.9	0.4	4.5	0.7	3.3
Floodwalls	0.0	0.0	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.1
Trails	2.3	0.4	2.1	0.7	4.3	0.3	0.4	0.8	1.7	4.3	0.5	0.3	0.7	1.8	4.5	0.4	0.3	0.8	3.0	4.9	0.4	0.1	0.5	3.4
Levees	0.0	0.0	0.5	0.0	0.3	0.0	0.3	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.3	0.1	0.2	0.0	0.0
Natural Gas Pipeline	0.0	0.0	0.3	0.0	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.2	0.0	0.1	0.0	0.0
Railroad	0.0	0.0	0.6	0.0	0.1	0.0	0.4	0.0	0.0	0.1	0.0	0.4	0.0	0.0	0.1	0.0	0.4	0.0	0.0	0.2	0.0	0.4	0.0	0.0
Sewer Lateral	0.0	0.1	0.3	0.3	0.1	0.0	0.2	0.3	0.0	0.1	0.1	0.2	0.3	0.0	0.2	0.1	0.1	0.4	0.3	0.3	0.0	0.1	0.3	1.6
Sewer Line	0.0	0.4	4.9	0.9	2.1	0.3	3.3	1.2	0.0	2.6	0.5	3.1	1.4	0.1	3.3	0.4	2.4	1.7	1.4	4.5	0.5	2.0	1.2	3.6
Sewer Outfall	0.0	0.0	0.7	0.0	0.1	0.0	0.5	0.0	0.0	0.1	0.0	0.5	0.0	0.0	0.1	0.0	0.5	0.0	0.0	0.1	0.0	0.5	0.0	0.2
Shoreline Protection	0.8	0.2	0.0	0.1	1.0	0.0	0.0	0.1	0.5	1.0	0.0	0.0	0.1	0.6	1.0	0.0	0.0	0.1	0.6	1.0	0.1	0.0	0.0	0.6
Storm Drains	0.1	0.3	3.4	0.2	1.0	0.3	2.6	0.3	0.0	1.2	0.3	2.6	0.4	0.1	1.5	0.3	2.4	0.5	0.6	2.3	0.3	2.0	0.3	1.2
Transmission Lines	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Water Main	0.0	0.3	4.3	0.2	2.5	0.2	2.3	0.5	0.0	3.0	0.5	2.0	0.8	0.0	3.8	0.4	1.4	1.2	0.5	4.6	0.3	1.2	1.0	2.7
Water Service	0.0	0.0	0.5	0.1	0.2	0.0	0.4	0.1	0.0	0.2	0.0	0.3	0.2	0.0	0.3	0.1	0.2	0.3	0.0	0.5	0.0	0.2	0.2	0.8

Note: Future development erosion is included in the analysis for comparing the "no action" impacts and costs to different management scenarios, even though no action is unlikely. Future development erosion totals are not included in the discussion in Section 5.2

Table C3: Exposure to Hazards
Building Type

Unit=Count	Current Conditions				Short-Term					Mid-Term					Long-Term					2100 and Beyond				
Land Use	Current Ocean Water Levels	Current Coastal Flooding and Waves	Current Coastal and River Flooding	Current Flooding with Wave Runup	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion
Cemetery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercial/Retail	0	0	24	0	0	0	24	0	0	0	0	24	0	0	0	0	24	0	0	2	0	22	0	0
General Industrial	0	0	9	0	0	0	9	0	0	0	0	9	0	0	0	0	9	0	0	9	0	0	0	0
Hotel/Lodging	0	0	2	1	1	0	2	0	0	1	0	2	0	0	2	0	3	1	0	3	0	2	1	0
Mixed Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mobile Home Park	0	0	172	0	0	0	172	0	0	0	0	172	0	0	0	0	172	0	0	2	0	170	0	0
Multi-family Residential	0	7	33	19	35	4	8	33	0	36	7	10	47	0	41	7	5	52	0	49	13	2	61	15
Public/Government	0	0	12	0	0	0	12	0	0	0	0	12	0	0	0	0	12	0	0	0	0	12	0	0
Recreation	4	1	8	0	10	1	4	4	0	12	2	4	7	0	17	2	2	7	0	21	2	3	2	0
Religious Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RV Park Sites	0	0	184	0	0	0	184	0	0	0	0	184	0	0	0	0	184	0	0	63	0	121	0	0
School/Educational Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Single-family Residential	0	0	66	39	16	8	48	39	0	16	7	49	46	0	17	2	49	70	4	50	7	18	91	75

Note: Future development erosion is included in the analysis for comparing the "no action" impacts and costs to different management scenarios, even though no action is unlikely. Future development erosion totals are not included in the discussion in Section 5.2

Table C4: Exposure to Hazards
Polygon Assets

Unit = Acres	Current Conditions				Short-Term					Mid-Term					Long-Term					2100 and Beyond				
Polygon Asset Description	Current Ocean Water Levels	Current Coastal Flooding and Waves	Current Coastal and River Flooding	Current Flooding with Wave Runup	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion	Future Ocean Water Levels with Beach Erosion	Future Coastal Flooding and Waves	Future Coastal and River Flooding	Future Coastal Flooding Wave Runup	Future Development Erosion
Beach	11.2	6.7	1.1	13.7	22.6	0.9	0.5	13.7	13.2	25.9	3.1	0.3	9.0	20.4	32.3	1.4	0.1	6.3	31.3	36.0	2.8	0.0	1.5	36.4
Coastal Bluffs	0.2	0.3	0.0	0.5	0.5	0.0	0.0	0.5	0.5	0.6	0.1	0.0	0.3	1.0	0.7	0.0	0.0	0.2	1.0	0.9	0.1	0.0	0.0	1.0
Coastal Structures and Barriers	0.1	0.1	0.0	0.3	0.1	0.0	0.0	0.4	0.1	0.1	0.1	0.0	0.3	0.2	0.1	0.1	0.0	0.3	0.3	0.4	0.1	0.0	0.0	0.5
Hardline Preserves	0.2	3.7	133.1	0.3	103.3	1.7	32.9	0.5	1.5	104.7	2.6	31.1	0.1	1.7	109.2	3.0	26.0	0.1	3.3	118.1	4.0	16.5	0.2	4.9
Parks	3.1	2.5	7.2	5.6	5.3	3.4	6.4	3.8	3.3	6.3	5.0	5.2	3.0	5.0	7.1	5.7	4.6	3.5	9.6	13.6	1.2	4.3	4.3	16.1
Rip Rap	0.1	1.5	0.2	4.9	0.9	1.0	0.0	4.8	0.6	1.4	1.2	0.0	3.9	3.0	2.3	1.2	0.0	3.2	6.8	4.9	0.6	0.0	1.3	6.8
Softline Preserves	0.0	0.0	20.1	0.0	5.4	0.0	14.5	0.0	0.0	5.6	0.0	14.4	0.0	0.0	5.7	0.0	14.3	0.0	0.0	5.7	0.0	14.3	0.0	0.0
Street Lights	0.0	0.1	0.5	0.3	0.3	0.0	0.3	0.4	0.0	0.5	0.1	0.3	0.3	0.1	0.6	0.1	0.2	0.4	0.5	0.7	0.1	0.2	0.3	1.1
Estuarine and Marine Wetland	20.7	5.3	28.5	2.9	39.3	1.1	16.1	0.9	17.4	41.1	1.2	14.7	0.5	20.4	45.7	0.9	10.6	0.4	21.7	55.7	0.2	1.6	0.0	21.9
Freshwater Emergent Wetland	0.0	0.0	28.0	0.0	18.8	0.0	9.2	0.0	0.0	18.8	0.0	9.2	0.0	0.0	18.8	0.0	9.2	0.0	0.0	19.5	0.0	8.6	0.0	0.0
Freshwater Forested/Shrub Wetland	0.0	0.0	44.3	0.0	35.6	0.0	8.5	0.0	0.0	35.6	0.0	8.5	0.0	0.0	35.6	0.0	7.9	0.0	0.0	36.0	0.0	7.8	0.0	0.0
Coastal California gnatcatcher	0.0	0.0	171.7	0.0	113.4	0.0	57.4	0.0	0.0	113.6	0.0	57.3	0.0	0.0	113.4	0.0	56.5	0.0	0.0	114.4	0.0	55.6	0.0	0.0
Least Bell's vireo	0.0	0.0	73.9	0.0	38.1	0.0	35.5	0.0	0.0	38.2	0.0	35.4	0.0	0.0	38.2	0.0	35.1	0.0	0.0	38.5	0.0	34.8	0.0	0.0
Southwestern willow flycatcher	0.0	0.0	81.5	0.0	71.9	0.0	9.2	0.0	0.0	72.1	0.0	9.1	0.0	0.0	72.1	0.0	8.7	0.0	0.0	72.3	0.2	8.4	0.0	0.0
Tidewater goby	0.8	4.3	49.1	0.4	50.9	1.9	1.2	0.6	2.3	50.7	2.8	0.9	0.1	2.5	50.8	2.9	0.6	0.1	4.0	50.7	3.4	0.4	0.0	5.5

Note: Future development erosion is included in the analysis for comparing the "no action" impacts and costs to different management scenarios, even though no action is unlikely. Future development erosion totals are not included in the discussion in Section 5.2

Appendix D

Transportation Exposure to Hazard Details

APPENDIX D
Transportation Exposure to Hazard Details

S. Coast Highway

The S. Coast Highway is exposed to riverine flooding under existing conditions in areas adjacent to Loma Alta Slough and Buena Vista Lagoon. The highway has experienced flooding at Buena Vista Lagoon previously, and this flooding is expected to continue and increase in the future. Because the S. Coast Highway currently experiences flooding, it is categorized as having a high exposure to hazard.

CA Route 78

CA Route 78 is exposed to riverine flooding under existing conditions just east of the I-5 junction according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation just south of the southwest corner of the Pacific Coast Plaza. The route elevation ranges from 16 to 20 ft NAVD in this area. Modeling done for the Buena Vista Lagoon Enhancement Project EIR by Everest International Consultants, showed that water levels under existing conditions could reach roughly 18 ft NAVD during the 1% annual chance event (Everest 2014). This indicates that the route would likely flood during this type of event. Because the CA Route 78 is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

CA Route 76

CA Route 76 is exposed to riverine flooding under existing conditions just east of the I-5 junction for about ¾ of a mile according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation south of the San Luis Rey River crossing CA Route 76 into Lawrence Canyon. Because the CA Route 76 is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Railroad

The Railroad is exposed to coastal flooding under existing conditions just east of the Oceanside Harbor according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation from the San Luis Rey River crossing Harbor Drive up to the railroad tracks. Because the railroad is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Harbor Drive

About 1 mile of Harbor Drive is exposed to coastal flooding under existing conditions just northeast and southeast of the Oceanside Harbor according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation from the San Luis Rey River covering portions of Harbor Drive. Because Harbor Drive is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

N. Pacific Street

N. Pacific Street is exposed to coastal flooding under existing conditions just south of the Oceanside Harbor where it meets Harbor Drive according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation from the San Luis Rey River covering the north-most portion of N. Pacific Street. Because N. Pacific Street is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Capistrano Drive

Capistrano Drive is exposed to riverine flooding under existing conditions just south of Capistrano Park according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation north of the San Luis Rey River crossing Capistrano Drive into Capistrano Park. Because Capistrano Drive is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Loretta Street

Loretta Street is exposed to riverine flooding under existing conditions just south of CA-76 according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation south of the San Luis Rey River crossing CA Route 76 into Lawrence Canyon, including the northern portion of Loretta Street. Because Loretta Street is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

N. Coast Village Way

N. Coast Village Way is exposed to riverine flooding under existing conditions just south of San Luis Rey River according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation south of San Luis Rey River crossing the road. Because N. Coast Village Way is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Breakwater Way

Breakwater Way is expected to be exposed to coastal flooding in the short-term just north of The Strand. The CoSMoS results 1% annual chance event mapping show inundation from the ocean along the west end of the road. Because Breakwater Way is expected to experience flooding in the short-term during the 1% annual chance event, it is categorized as having a high exposure to hazard.

The Strand

The Strand is exposed to coastal flooding and coastal flooding and waves under existing conditions between the Oceanside Pier and San Luis Rey River according to the CoSMoS results and the FEMA flood mapping. The FEMA 1% annual chance event mapping shows inundation south of Surfrider Way. Because the Strand is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Mira Mar Place

Mira Mar Place is expected to be exposed to coastal flooding under existing conditions during a 1% annual chance storm according to the CoSMoS results. CoSMoS results show flooding from the Strand south of Mira Mar Place flooding north, covering the entirety of Mira Mar Place. Because Mira Mar Place is expected to experience flooding in the short-term during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Surfrider Way

Surfrider Way is exposed to coastal flooding under existing conditions at the intersection with the Strand according to the CoSMoS results and the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation in the roundabout at the western end and CoSMoS shows flooding just past the intersection with the Strand. Because Surfrider Way is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Seagaze Drive

Seagaze Dive is exposed to coastal flooding wave runup under existing conditions at the intersection with the Strand. CoSMoS results show coastal flooding wave runup at the west end of Seagaze Drive. However, the CoSMoS results show the exposure is expected to stay the same through 2100. Because Seagaze Drive is currently expected to experience wave runup flooding during the 1% annual chance event, it is categorized as having a medium exposure to hazard.

Wisconsin Avenue

Wisconsin Avenue is exposed to coastal flooding wave runup under short term conditions at the intersection with the Strand according to the CoSMoS results and the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation at the western end and CoSMoS shows wave runup flooding at the intersection with the Strand. Because Wisconsin Avenue is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Hayes Street

Hayes Street is expected to be exposed to future coastal flooding wave runup under mid-term conditions at the furthest west portion of the street according to the CoSMoS results. The CoSMoS results show coastal flooding wave runup at the west end of the road in the mid-term. Because Hayes Street is expected to experience wave runup flooding during the 1% annual chance event in the mid-term, it is categorized as having a medium exposure to hazard.

S. Pacific Street

S. Pacific Street is exposed to riverine flooding under existing conditions south of Loma Alta Creek according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation of the road from Loma Alta Creek. Because S. Pacific Street is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

Morse Street

Morse Street is expected to be exposed to future coastal flooding wave runup under mid-term conditions at the intersection of S Pacific Street according to the CoSMoS results. Future coastal flooding wave runup is seen towards the west end of Morse Steet from the Pacific Ocean. Because Morse Street is currently expected to experience flooding during the 1% annual chance event in the mid-term, it is categorized as having a medium exposure to hazard.

St. Malo Beach

St. Malo Beach is exposed to riverine flooding under existing conditions just west of Pacific Street according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation of the road from Buena Vista Lagoon. Because St. Malo Beach is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

S. Vista Way

S. Vista Street is exposed to riverine flooding under existing conditions just south of CA-78 according to the FEMA flood maps. The FEMA 1% annual chance event mapping shows inundation north of the Buena Vista Lagoon, covering a majority of S. Vista Way. Because S. Vista Way is currently expected to experience flooding during the 1% annual chance event, it is categorized as having a high exposure to hazard.

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