2016 City of Monterey
Final Sea Level Rise and Vulnerability Analyses, Existing Conditions and Issues Report

3/10/2016

Submitted to City of Monterey

By

Revell Coastal, LLC
125 Pearl Street, Santa Cruz, CA 95060
revellcoastal@gmail.com | 831.854.7873

City of Monterey California

Revell Coastal
Surf. Sand. Sustainability.

EMC PLANNING GROUP

Contents

Figures

Page

Tables

Page

Photographs

Page

Executive Summary

ES.1 Purpose

The process of examining existing conditions and issues is the first step for a community to understand the threat of climate-induced coastal hazards, such as sea level rise.

The 2016 City of Monterey Existing Conditions and Issues Report (Report) provides a science-based assessment that includes extensive field data gathering, and compilation of existing data and information,

ES.2 Definitions

Planning Horizon: The planning horizon is the future time that forecasts of climate impacts are made and the time that an organization will look into the future when preparing a strategic plan.

Vulnerability Assessment and Sector Profiles: A vulnerability assessment is the process of identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in a system. There are a variety of vulnerable "sectors" within the City, ranging from building structures, oil and gas, coastal armoring, water supply, and transportation.

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

ES.3 Report Overview

Planning Background

This section describes the purpose of the report, the study area boundary, existing conditions, the planning process that was conducted as part of preparation for the report, and the connection with the California Coastal Commission's (CCC's) 2015 Sea Level Rise Policy Guidance Document.

Physical Setting

This section characterizes developed areas, natural resources, creeks, coastal and shoreline areas, and elevation. Further details are provided that elaborate on the unique geology and geomorphology of the Monterey shoreline, including cliff erosion rates and shoreline change rates.

Climate Science

The differences between climate "cycles" and climate "change" are provided for background purposes. Projections of climate-induced impacts created by temperature and precipitation patterns, wildfire, extreme event flooding, and sea level rise are provided.

Vulnerability by Sector

Hazard projections and vulnerability assessment methodologies and assumptions used to model and map coastal hazards are presented for use in determining future levels of vulnerability for the various planning horizons (i.e., 2010, 2030, 2060, and 2100. Coastal flood hazards are presented and include the following:

- Wave flooding (ponding)
- Barrier beach flooding
- Inundation (tidal)
- Long-term and storm-induced coastal erosion including cliff and dune erosion

Potential impacts on urban uses and natural resources are described, based on the five coastal process hazards as the foundation for the vulnerability assessment. Based on the characteristics of the City's coastline and watersheds and input from the City and public, Revell Coastal analyzed eleven sectors in the vulnerability assessment. The sector profiles are presented in Appendix A and are discussed in more detail throughout the report:

- Land Use and Structures
- Roads and Parking
- Public Transportation
- Wastewater
- Water Supply
- Storm Water
- Hazardous Materials
- Public Access
- Emergency Services
- Public and Military Facilities
- Biological Resources

ES.4 Key Findings

Overall Findings:

The following are key findings identified as a result of analyses in this report:

- Coastal hazards with 5 feet of sea level rise pose greater risk to the City than a Federal Emergency Management Agency (FEMA) mapped 500-year storm event.
- Coastal flooding poses the largest vulnerability to public transportation with the Recreational Trail and Del Monte Avenue bus routes being the most vulnerable.
- Vulnerabilities to all public transportation metrics show a threshold between ~1 and 2 feet of sea level rise during which coastal flooding and erosion impacts escalate rapidly.
- Evacuation impacts occur primarily along the Del Monte Ave corridor.
- Most existing Hazardous Materials Business Plan (HMBP) are located in the harbor and are associated with coastal dependent uses.
- One lift station in the City affected potentially by coastal flooding by 2030 and by coastal erosion by 2060.

Vulnerabilities by Planning Horizon

The following is a summary of the resulting vulnerabilities organized by Planning Horizons:

2010 (Existing) Vulnerabilities

- Nearly a mile of the Monterey Interceptor wastewater infrastructure is vulnerable to coastal erosion.
- Coastal erosion primarily impacts open space and residential parcels.
- Existing hazards to most sectors are focused around Del Monte Lake and gradually spread toward Lake El Estero and lower Downtown.
- 45 percent of the Recreational Trail is vulnerable to coastal erosion under the existing conditions.

2030 Vulnerabilities

(<1 foot of sea level rise)

- Substantial increase in coastal flooding potentially entering sewer manholes and overwhelming the aging system.
- Commercial and visitor serving accommodations are impacted heavily.
- Parking lots servicing San Carlos Beach and Wharf #2 face the highest existing threat with a threshold between 2030 and 2060 when vulnerabilities to parking and roads increasing substantively.
- The majority of vertical accesses are vulnerable to coastal erosion.

2060 Vulnerabilities

(~ 2 feet of sea level rise)

- Pump station near Roberts Lake is vulnerable to coastal flooding.
- Coastal erosion vulnerabilities to residential parcels escalate between 2060 and 2100.
- The number of structures impacted by coastal flooding escalates substantially between 2 and 5 feet of sea level rise.

2100 Vulnerabilities

(~ 5 feet of sea level rise)

- Coastal flooding will temporarily impact 2,632 parking spaces
- The number of vulnerable stormwater outfalls more than doubles between existing and 2100 and may increase localized flooding.
- Water supply system exposed to coastal erosion of hydrants, valves and pipes which may damage the system, while coastal flood impacts may hinder ability to manage the system.
- By 2100 all vertical and lateral accesses are vulnerable to coastal hazards.
- Coastal flooding is highest risk by 2100 to all types of land uses, with coastal erosion being the second highest by 2100.
- Tidal inundation begins to cause routine flooding of 319 structures with 5 feet of sea level rise.
- Two public facilities, the Monterey Sports Center, and the Monterey Conference Center at the Portola Plaza hotel, both assets with important community values are vulnerable with 5 feet of sea level rise,

Positive Findings

- There are no government operational facilities at risk from climate induced coastal hazards with up to 5 feet of sea level rise.
- No industrial parcels in the City are impacted by 5 feet of sea level rise
- NO HMBP or Leaking Underground Fuel Tanks (LUFT) are exposed to coastal erosion with up to 5 feet of sea level rise.
- No water supply wells are projected to be vulnerable to coastal hazards with 5 feet of sea level rise.

ES.10 Sector Profile Results

Sector profiles that summarize the findings and recommendations that can be used in future decision-making are included in Appendix A. Each sector has its own profile, complete with a vulnerability map and 2-page description of findings for ease of communication. The combination of this executive summary and Appendix A are intended to summarize key findings of the report.

ES.11 Biological Report

A comprehensive review of the existing biological resources, sensitive habitats and related species authored by EMC Planning Group is included in Appendix B.

1. Planning Background

1.1 Introduction

The California Coastal Act requires local governments in the state's Coastal Zone to create and implement Local Coastal Programs (LCPs). Each LCP consists of a Coastal Land Use Plan and an Implementation Plan. Using the California Coastal Act, the California Coastal Commission (CCC) and local governments manage coastal development, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion. Sea level rise and the changing climate present new management challenges with the potential to significantly threaten many coastal resources, including both natural and public access. One of the CCC's priority goals is to coordinate with local governments, such as the City of Monterey (City), to complete a LCP in a manner that addresses sea level rise.

In order to address sea level rise and associated hazards in the City's LCP project, the City and its consultant team prepared this DRAFT 2016 City of Monterey Existing Conditions and Issues Report (Report). The purpose of this report is to provide technical analysis using climatic modeling to support the City's effort to incorporate a range of coastal and climate change hazards into the City's planning and regulatory processes. This information will assist the City in making more informed decisions regarding land use and development standards from the project level to the plan level.

1.2 Location

The City of Monterey is located on the Pacific Ocean in Central California on the South side of Monterey Bay in Monterey County. The City is situated along California Highway 1 (Highway 1), the major coastal highway running the length of the state (Photo 1-1). Monterey is approximately 115 miles south of San Francisco and 350 miles north of Los Angeles.

The Coastal Zone and City boundaries are seen in Figure 1-1, *City of Monterey Overview*, along with neighboring jurisdictions. The City covers 8.4 square miles of land area, or 5,382 acres. Approximately 3.5 square miles of water area in Monterey Bay are also within the Monterey City limits. The adjacent jurisdictions include the following: City of Seaside, City of Pacific Grove and County of Monterey, and the Monterey Bay National Marine Sanctuary. The Coastal Zone in Monterey can largely be separated into distinct landscapes.
Situated on a rocky peninsula adjacent to the Monterey Bay National Marine Sanctuary, the City is an area of exceptional natural beauty with portions on a low-lying coastal plain fronted by sand dunes. A portion of the City, including its 3-mile Pacific shoreline, is within the California Coastal Zone. The Coastal Zone boundaries are shown in Figure 1-1.

The City can be identified by various sub-areas within the City. Throughout the report these sub-areas are referred to provide readers a spatial reference. These sub-areas include: Cannery Row, Waterfront, Downtown, Del Monte, and Skyline Forest (Figure 1-1).

Photo 1-1. Oblique of City of Monterey (Photo: Shutterstock)

1.3 Existing Development

Currently, the City's resident population is approximately 30,000 persons. According to the City's 2004 General Plan Update EIR, implementation of the General Plan Update could result in development of approximately 2,000 new homes and an increase in population of over 4,000 people by the projected build out of the City (City of Monterey General Plan Update Environmental Impact Report, 2004). Over time, the City has managed to largely retain its image as a small-scale community that is predominately residential and visitor-serving in nature. Consistent efforts to protect and maintain the wide range of aesthetic physical attributes, namely forested ridges, scenic creek corridors, beach shoreline and rocky coast, and the Monterey Bay, have resulted in the City retaining much of its aesthetic appeal.

The majority of land in the City already contains some development. Primary land uses include residential development at low to moderate density, and visitor-serving, professional office, and retail commercial uses. Commercial uses are predominant in the downtown area, along Lighthouse Avenue, the Cannery Row area, and along North Fremont Street. The City's industrial activity is focused in the existing 300-acre Ryan Ranch area and along the northern side of Highway 68. Industrial uses do not occur in any other parts of the City. Fortunately, Monterey's growth has responded to the existing natural features: downtown commercial on the flatter old marsh area, lighter commercial and medium-density residential on the sloping mesas, neighborhoods separated by the wooded canyons, and low-density residential in the steep wooded foothills.

1.4 Other Environmental Conditions

The Monterey Bay Marine Sanctuary's Water Quality Protection Program includes educational, monitoring, and development

Figure 1-1: City of Monterey Overview

City of Monterey

Coastal Zone Boundary

The data utilized for purposes of this Report was collected from various sources and is not to be construed as "legal description." This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.

Revell Coastal
Surf. Sand. Sustainability.

City of Monterey California

EMC Planning Group

actions to protect the water quality of Monterey Bay and its tributaries. This program operates under the umbrella of the Coastal Commission's Critical Coastal Areas Program, which coordinates water quality efforts (Monterey Bay National Marine Sanctuary, 1996).

1.5 Coastal Governance

Land use planning for addressing coastal erosion is shared between multiple agencies in California. The federal Coastal Zone Management Act (CZMA) requires that state coastal management programs include a "… planning process for shoreline erosion… and restore areas that have been adversely affected by such erosion" (Section 306d.2.I. of the CZMA, as amended through PL 104-150, 1996). The California Coastal Act assigns primary responsibility for carrying out the California coastal management program to the California Coastal Commission and the State Coastal Conservancy. The Public Resources Code (Section 3000 et seq.) designates the Coastal Commission as the lead agency responsible for carrying out California's coastal management program by planning for and regulating development in the coastal zone consistent with the policies of the Coastal Act.

The policies of the Coastal Act deal with public access to the coast, coastal recreation, the marine environment, coastal land resources, and coastal development of various types, including energy facilities, ports, and other industrial development. Public Resources Code (Section 31100 et seq.) established the California Coastal Conservancy complementing the planning and regulatory activities of the Coastal Commission through coastal land acquisition and resource restoration and enhancement programs. The Coastal Conservancy uses entrepreneurial techniques to purchase, preserve, improve, and restore public access and natural resources along the California coast. (Resources Agency of California 2001).

Under state and federal laws, there are a number of agencies with responsibility to plan for and respond to coastal erosion issues. Responding to coastal erosion at the state level is the responsibility of the Department of Boating and Waterways. The Department of Boating and Waterways is California's primary agency responsible for working to restore eroded beaches and protecting public coastal infrastructure. Sections 65 through 67.3 of the State Harbors and Navigation Code assign the responsibility for studying shoreline erosion, constructing protective works, and administering state funds for the local share of federal projects to the Department.

Sections 69.5 through 69.9 assign responsibility to the Department for administering the California Public Beach Restoration Program. The mission of the program is to preserve and protect the California shoreline by restoring and maintaining natural and recreational beach resources and minimizing economic losses caused by natural and human-induced beach erosion.

1.6 The History of Monterey's Local Coastal Program

The City approved its most recent General Plan in January 2005 (Resolution No. 05-03), with the last amendment approval occurring in August 2013 (Resolution No. 13-131). More recently, the City was awarded a grant from the California Coastal Commission (CCC) in 2014 to complete a Local Coastal Program for certification by the CCC. In the 1980s, the City divided its coastal planning area into five sub-areas – Cannery Row, Harbor, Del Monte Beach, Skyline and Laguna Grande. The Laguna Grande Land Use Plan was never certified, and an implementation plan has not been developed. As part of this grant, the City intends to update, consolidate and adopt one Land Use/Implementation Plan for the City.

The first major project objective was to develop an existing conditions and issues report for public review based on technical data, stakeholder input (NOAA, Coastal Commission staff, etc.) and public workshops. This Report fulfills these grant requirements. According to the grant, the Report must include a land use and infrastructure inventory. Major planning issues are to be identified and explored such as the range of sea level rise projections for 2030, 2060, and 2100 relevant to the planning area based on the 2012 NRC Report. These projections will be modified to account for local conditions.

1.7 LCP Outreach Process

Following this Report, the next step for the LCP grant will be to draft the LCP vision and goals through a thorough Outreach Process. This work will include a public workshop, subcommittee meeting, and meetings with coastal staff. The Planning Commission and City Council will also be asked to accept the vision and goals. As the LCP grant is in its early stages, the City has provided the following to support outreach:

- A robust public outreach program, and will submit a draft of the outreach plan to CCC staff for review before finalizing to ensure outreach fulfills requirements of the Coastal Act. Stakeholders include the Monterey Bay National Marine Sanctuary (MBNMS), Monterey County, Pacific Grove, and other regional efforts as feasible.
- The City has generated web page, social media interface, and newsletters to obtain public input and update the public about upcoming meetings, draft documents, and the project's overall schedule and progress. http://monterey.org/en-us/Departments/Plans-Public-Works/Planning/Planning-Projects/Local-Coastal-Program-Update
- A sea level rise walk is scheduled for February 2016, which will highlight for community participants areas where flooding is anticipated in the future to increase public awareness of the unique challenges that climate change poses for the City and coastal resource protection.

1.8 Next Steps in the Planning Process

To assist with the planning process for the Local Coastal Program, the City has drafted a number of documents, including the recent Draft Waterfront Master Plan (June 2015). The Waterfront Master Plan will serve as an implementation tool for the General Plan and Local Coastal Land Use Plan (LUP) and replaces all existing land use documents that address the Waterfront planning area, which is bordered by the Coast Guard pier to the west and Sloat Avenue to the east, Del Monte Avenue to the south, and the north end of the harbor to the north.

Waterfront Master Plan

Specifically, the Waterfront Master Plan achieves the following:

- Addresses the relationship of the waterfront to Custom House Plaza, the Monterey Conference Center, and the downtown in terms of parking and mobility;
- Defines the types of commercial and recreational land uses that are appropriate and desirable for the waterfront;
- Defines the design and character of the planning area; and
- Addresses the potential effects of coastal erosion and sea level rise.

The 2015 Draft Waterfront Master Plan contains the following suggested adaptation recommendations to address sea level rise which should be considered in the policy development stages of the LCP. Some of these recommendations lack the economic basis for supporting these decisions so other resources (e.g. Section 3.5), should be considered.

- Develop multi-phased mitigation plan for sea level rise/coastal erosion.
- Construct seawall at foot of Wharf #2 along the beach that ties into the pedestrian promenade and continues to allow convenient public access to the beach.

- As an adaptation strategy, remove the Beach House and Monterey Bay Kayak buildings but preserve the Beach House platform as a protection/barrier.
- Institute warning system to alert the public of potential tsunami event.
- Require all new waterfront construction to be designed/located to survive 100-year flood zone.

As mentioned above, the early forms of the Land Use Plans were divided into the following sub-areas: Cannery Row, Harbor, Del Monte Beach, Skyline, and Laguna Grande.

Laguna Grande/Roberts Lake Local Coastal Program Land Use Plan (1981 – never certified)

This LCP was a joint effort between the cities of Monterey and Seaside through a Joint Powers Agreement (JPA). However, the original 1981 and the 2010 amendment were never certified by the CCC. The jurisdictional boundaries represent an artificial separation of the former estuarine complex, composed of Laguna Grande and Roberts Lakes, which was formerly a single lagoon with an outlet to the ocean. The LCP contains policies to provide for public and coastal-related use and access that are consistent with the natural coastal resources, as well as land use and development policies that are consistent with the Coastal Act.

Skyline Plan Local Coastal Program Land Use Plan (1992)

When the Coastal Zone boundary was drawn in early 1977, the Scenic Drive area was part of the Del Monte Forest and the County of Monterey. With annexation of the Scenic Drive area to the City, Coastal Zone jurisdiction was transferred to the City and comprises 107 acres. Additionally, this LCP segment includes the upper portion of the Monterey Presidio, There were numerous objectives within the LCP including maximizing public access to coastal vistas, views, and view corridors in the Scenic Drive area, to allow each property owner an economic return on land owned, to minimize disturbance to the surrounding land area, and to preserve and enhance the natural forested backdrop of Monterey.

Del Monte Beach Local Coastal Program Land Use Plan (2003)

The Del Monte Beach Local Coastal Program (LCP) area is in the eastern portion of the City of Monterey's coastal zone. Figure 1 illustrates its location in relation to the other LCP segments in the City. It adjoins the Laguna Grande/Roberts Lake LCP area to the southeast and the Harbor LCP area to the west. The Del Monte Beach LCP area constitutes approximately 220 acres of land bayward (north) of, and including, Del Monte Avenue and a section of State Route 1. Figure 1 presents the boundary of the LCP area. It encompasses shoreline property along Monterey Bay from the U.S. Naval Postgraduate School (NPS) to the eastern city limits at Humboldt Street. Key issues include the desire to retain the remaining dune areas in open space and to have new public recreation areas on this section of the Monterey coastline, and the need for residential design guidelines, which address view preservation and neighborhood compatibility.

Monterey Harbor Local Coastal Program Land Use Plan (2003)

As permitted by the Coastal Act, the City prepared the original LCP in five geographical segments, with the Harbor LUP as the fifth and final segment. The Monterey Harbor segment of the City is located between Cannery Row to the west and Del Monte Beach to the east. The LCP area includes approximately 115 acres of land fronting on the southern portion of Monterey Bay. Major properties within the LCP area include Fisherman's Wharf and Wharf #2, and the Monterey State Historic Park area.

Cannery Row Local Coastal Program Land Use Plan (2004)

Cannery Row is the original location of Monterey's prolific sardine industry. Since the collapse of the sardine industry in 1960, Cannery

Row now consists of many visitor-serving businesses and the Monterey Bay Aquarium, which serves as a major attraction for Monterey. The LCP contains policies to provide for public and coastal-related use and access that are consistent with the natural coastal resources as well as sets land use and development policies that are consistent with the Coastal Act.

In addition to consolidating the various Land Use Plan documents and submitting an Implementation, the City's grant requires the City to analyze and plan for sea level rise. The intent of this report is to meet Steps 1–3 of the CCC policy guidance (Figure 1-2).

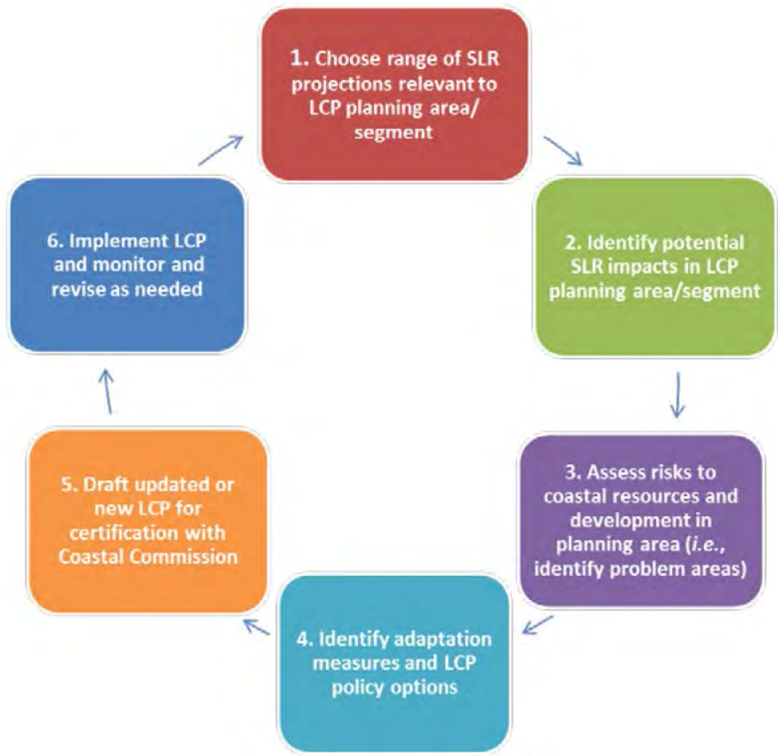


Figure 1-2. California Coastal Commission Guidance for Including Sea Level Rise into Local Coastal Programs

1.9 2015 California Coastal Commission Sea Level Rise Policy Guidance

In August 2015, the CCC adopted the Sea Level Rise Policy Guidance to aid jurisdictions in preparing for sea level rise in LCPs, coastal development permits (CDPs), and regional strategies. The document outlines specific issues that policymakers and developers may face as a result of sea level rise, such as extreme events, challenges to public access, vulnerability and consistency with the California Coastal Act. The policy guidance document also lays out the recommended planning steps to incorporate sea level rise into the legal context and planning strategies to reduce vulnerabilities and inform adaptation planning (Figure 1-2).

The policy guidance has a strong emphasis on incorporating coastal hazards and sea level rise into LCP planning and using soft or green adaptation strategies which mimic or enhance natural processes and defenses, rather than those gray or hard engineering intensive strategies. The following are specific steps that are outlined in the document:

Step 1. Establish the Projected Sea Level Rise Ranges

Consistent with the CCC policy guidance, the City is evaluating a worst-case scenario: the 62.6 inches by 2100 scenario projected by the National Research Council (NRC) for South of Cape Mendocino. This includes a regional assumption of 1.5 mm of subsidence annually. The City has selected 2010, 2030, 2060, and 2100 as the most relevant planning horizons because these time horizons align with modeling completed in 2014 to support coastal management, planning, and LCP updates. 2010 represents the most recently flown LIDAR for the Monterey coastline and therefore is the baseline for this analysis. Additionally, these time horizons align with the City's future General Plan buildout (2024). The intermediate planning horizon, 2060, was selected because it aligns with the lifespan of a typical building constructed as part of the 2024 Plan. Finally, 2100 is the longest planning horizon since this is the last year that most sea level rise projections and guidance consider. This horizon is roughly a typical structural life expectancy for large infrastructure projects, such as bridges, which often prove to be significant constraints to large scale adaptation planning and nature based adaptation solutions.

Step 2. Identify Potential Impacts from Sea Level Rise

Based on the 2014 Monterey Bay Sea Level Rise Vulnerability Assessment Report, the potential hazards for the City include dune erosion, cliff erosion, coastal flooding, wave run-up, tidal inundation, and storm erosion (ESA 2014). Given the boundaries and setting of the City, the two most dominant hazards are 1) coastal flooding associated with wave run-up and 2) coastal erosion. It should also be noted that the influence of sea level rise on creek flood extents and stormwater drainage is unknown. We based our initial analysis on the existing FEMA maps and recommend future work to accomplish modeling of the climate impacts on coastal creek flood extents.

Step 3. Assess the Risks and Vulnerabilities to Coastal Resources and Development

The following sectors were determined to experience some form of existing or future risk and related vulnerability to sea level rise (e.g., dune erosion and/or coastal flooding):

- Land Use and Structures
- Roads and Parking
- Public Transportation
- Wastewater
- Water Supply
- Storm Water
- Hazardous Materials
- Public Access
- Emergency Services
- Public and Military Facilities
- Biological Resources

2. Physical Setting

2.1 Climate

Episodic winter storms cool foggy summers, and warm “Indian summer” fall seasons characterize the Mediterranean climate of this region. August temperatures average about 68° Fahrenheit while January temperatures average about 58° F. Precipitation is variable, but averages about between 16.12 and 21.33 inches across the city depending on which rain gage is considered. Rainfall primarily occurs in the winter months, with actual rainfall amounts varying widely depending on tropical moisture in the subtropical Pacific. El Niño conditions can increase this subtropical moisture; many of the wettest years on record occurred during El Niño years.

2.2 Geology

The City of Monterey is situated in Central California coast at the southern end of the Monterey Bay. The City spans the sandy dune-backed shoreline of Bay and the rocky granitic promontory of the Monterey Peninsula.

The granitic Monterey Peninsula has formed parallel to the San Andreas Fault by a series of complicated tectonic movements which have shaped Monterey’s coastline with varying levels of uplift and subsidence. The orientation of the shoreline is primarily controlled by faults along the Monterey Bay Fault Zone to the East and the Palo Colorado – San Gregorio Fault zone to the West (Greene 1977).

The dunes of Southern Monterey Bay have been created during lower sea level rise stands in the Pleistocene (>12,000 years ago) and the Holocene (<12,000 years ago) when the Salinas River was at a steeper gradient and discharged much more sediment to the coast (Cooper 1967). Wind transport formed the dunes over time and waves forced the sand south toward the City of Monterey.

2.3 Coastal Processes

The coastal processes of tides, waves, and ocean currents shape the coastline of the City of Monterey.

Tides - The tides in Monterey are mixed, predominantly semi-diurnal and are composed of two low and two high water levels of unequal heights per 24.8 hour tidal cycle. Typically, the largest tide ranges in a year occur in late December to early January. A tide recorder has been in continuous operation at Monterey on Wharf #2 since 1964.

Maximum tide elevations are due to astronomical tide, wind surge, wave set-up, density anomalies, long waves (including tsunamis), climate related El Niño, and Pacific Decadal Oscillation events. On longer time scales, sea level rise becomes increasingly important.

Waves – The waves that approach the Monterey Peninsula are characterized by three dominant modes. The northern hemisphere waves typically are generated by cyclones in the north Pacific during the winter and bring the largest waves (up to 25 feet). The southern hemisphere waves are generated in the Southern Ocean during summer months and produce smaller waves with longer wave periods (> 20 seconds). Local wind waves are generated throughout the year either as a result of storms coming ashore during the winter, or strong sea breezes in the spring and summer (Storlazzi and Field 2000).

2.4 Geomorphology

Southern Monterey Bay is its own littoral cell or sand compartment with sources of sand from the Salinas River and actively eroding dunes. The littoral cell extends from Wharf 2 in Monterey to the Monterey Submarine Canyon. The southern Monterey Bay has a history of sand mining, which exacerbates coastal erosion (Thornton et al 2006).

Along the City coastline there is a wide variety of coastal morphologies. Along Del Monte there are wide sandy beaches such as along Del Monte Beach and Sand City. Within the waterfront area, there are rocky intertidal areas along the sheltered shoreline behind the breakwater. Along Cannery Row, there are steep granite seacliffs with narrow pocket beaches such as McAbee and San Carlos beaches.

Sand along Del Monte Beach arrives to the beach from the Salinas River and erosion of the sand dunes in Monterey Bay. The sand is largely transported to the south until it reaches the Wharf #2 seawall. The sand is then transported along the seawall to offshore areas with some of the sand possibly reaching the Monterey Harbor entrance and travelling into the Harbor. The harbor breakwater also plays a large role in the local coastal processes in that it blocks much of the northern wave energy from reaching Del Monte Beach. The width along this beach can fluctuate seasonally, and year to year. Areas behind the beach have been, and will continue to be, subject to wave run-up and overtopping, as well as erosion (Combellick and Osbourne 1977, Thornton 2006, PWA 2008).

Sand along the Monterey Peninsula is largely derived from localized cliff erosion and transported from west to east along the Peninsula toward the Harbor.

2.5 Shoreline Change Rates

Shoreline change either accretion or erosion results from a combination of sediment supply, coastal processes and human activities. If sediment supply exceeds sediment removal then the coast will accrete seaward; if there is more sediment removed than supplied, the coast will erode. It is also important to note that there are long term changes caused by sediment supply, and sea level rise and short term or event based erosion caused by large storm events.

Monterey beaches experience seasonal cycles during which winter storms may remove significant amounts of sand, creating steep, narrow beaches. In the summer, gentle waves return the sand, widening beaches and creating gentle slopes. Because there are so many factors involved in coastal erosion, including human activity, sea-level rise, seasonal fluctuations, and climate change, sand movement will not be consistent year after year in the same location.

Dune deposits, are highly susceptible to coastal erosion from waves and tidal events. Erosion potential varies along the length of the coast. Variability in erosion rates are caused by several factors including sea level, wave patterns influenced by the form of the ocean floor, storm patterns, and the structure and character of dunes in localized areas. Historic average coastal dune retreat rates have been highest in the former Fort Ord area, averaging up to eight feet per year. Average erosion rates decrease down coast to about three to five feet per year in Sand City. Further south, within the City, average erosion rates have been measured between 1 and 2 feet/year (Hapke et al 2006, PWA 2008, ESA 2014). Coastal erosion is a significant factor for any development proposed along the margin of Monterey Bay.

2.6 Cliff Erosion

Cliff erosion is an important factor to consider along the Monterey Peninsula. Given the hard granitic cliffs, failures are typically a rock topple type of failure on the order of 1-5 feet. A large failure would not likely be much larger than 10 horizontal feet with the resulting material serving to reduce wave energy on the seacliff until the talus is removed.

Griggs and Savoy (1985) calculated 60 year seacliff erosion rates for the peninsula from aerial photograph interpretation. They calculated the erosion rates to be less than 3 cm/year (~1 inch/year) for more than 90% of the peninsula except in the area of highly developed Monterey waterfront, where the erosion rates were greater than 23.6 inches/year.

Others using historic topographic maps and new LIDAR topographic data have calculated average cliff erosion rates up to 8.5cm/year (3.3 inches/year) for the granite cliffs around the entire Monterey Peninsula (Hapke and Reid 2007).

2.7 Hazards

FEMA maps delineate coastal and creek flood hazards as part of the National Flood Insurance Program. This program requires very specific technical analysis of watershed characteristics, topography, channel morphology, hydrology, and hydraulic modeling to map the extent of existing watershed–related, and wave run-up related flood hazards. These maps, representing existing 100-year and 500-year flood hazards (1 percent annual chance of flooding and 0.2 percent, respectively) are known as the FIRMs and determine the flood extents and flood elevations across the landscape. The effective date of the existing FIRM maps for Monterey is 4/2/2009 Map #06053C0307G, Map #06053C0326G, Map #06053C0328G, Map #06053C0309G, and Map #06053C0306G). Figure 2-1 illustrates the existing FEMA 100-year and 500-year flood hazards.

The City's entire shoreline, piers, wharfs, harbor, and beaches are located in a Coastal High Hazard Area or V Zone subject to high velocity wave action such as the impact of waves and waterborne debris and the effects of severe scour and erosion as delineated on the FEMA FIRM (Panel 0307G).

The area east of Wharf #2 is within the AE FEMA flood zone, an area inundated by the 1% annual (100-year) flood event, which is also subject to flooding from wave overtopping during severe storm events. The City currently places a six-foot high sand berm adjacent to Monterey Municipal Beach from November to February every year to reduce the occurrence of wave overtopping. However, the berm does not completely eliminate these storm impacts.

Historically major flooding has occurred in 1938, 1941, 1943, 1952, 1958, 1969, 1958, 1969,1978, 1983, 1995, and 1997, with most of the flooding in the City reported along Del Monte Avenue and Fremont Street near El Estero (FEMA FIS 2009).

Photo 2-1. Flooding along Del Monte Ave (Photo: City of Monterey)

Existing Creek Flooding

Historic flooding is known to occur around the City (Photo 2-2). FEMA flood maps and base flood elevations for the Lakes and Esteros are shown in Table 2-1 and Figure 2-1.

Table 2-1. FEMA Coastal Base Flood Elevations for Water Bodies in Monterey City limits

Water Body	Base Flood Elevation (NAVD88)
Laguna Grande	17 feet
Roberts Lake	16 feet
Del Monte Lake	15-18 feet
El Estero	NA

Existing Coastal Hazards

Coastal erosion and coastal flooding are caused by large storm waves coupled with high tides. FEMA does not include coastal erosion or sea level rise in the mapping of coastal hazards.

Table 2-2 below shows the range of FEMA-modeled creek flood hazard zones.

Table 2-2. FEMA Coastal Base Flood Elevations for Shoreline Segments in Monterey City Limits

Shoreline Segment	Base Flood Elevation (NAVD88)
Cannery Row	20 feet
Inside Harbor	10 feet
Del Monte Beach	122 feet

FEMA is currently remapping the Pacific Coast flood maps with final results expected in 2018.

FEMA repetitive loss data shows that there have not been any parcels with multiple claims against the National Flood Insurance Program.

Photo 2-2. Wave run-up in December 2015 at Window to the Bay Park (Photo: P. Kinison Brown)

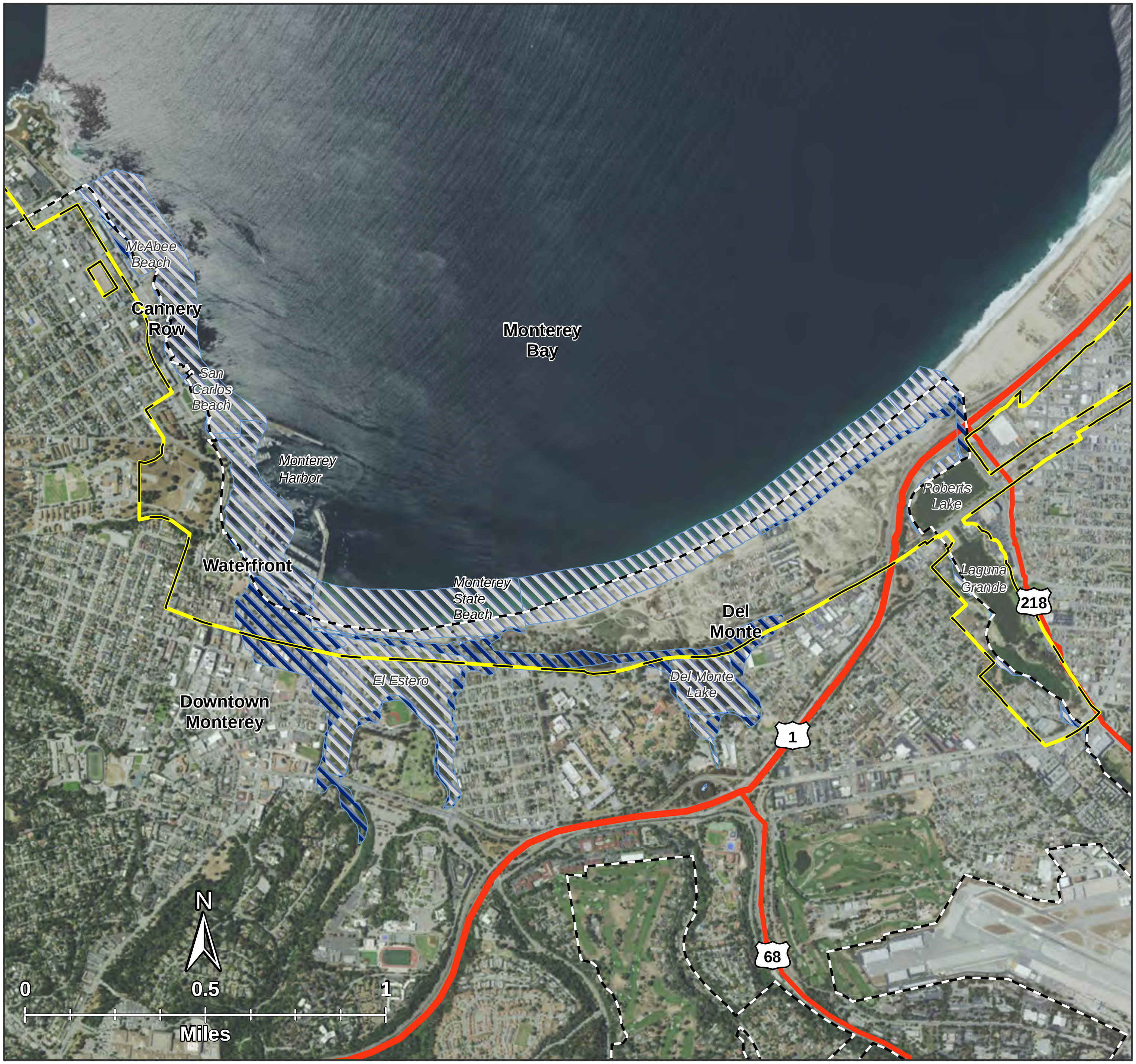
Historic Storm Impacts

Coastal and creek flood hazards have historically occurred across Monterey. Significant wave events in 1943, 1958, 1982–83, 1997–98, 2002, 2007, and 2015 have demonstrated that the coast is a dynamic and hazardous environment (Photo 2-1). Many of these storm events are associated with El Niño events.

In addition, storm water flooding combined with high tides and storm surge has caused substantial flood damages, particularly in the area around Del Monte Avenue (Photo 2-2) and (Photo 2-3). This area is currently mapped in FEMA's 500-year flood zone (0.02% annual chance event).

Photo 2-3. Del Monte Avenue, February 1998 (Photo: City of Monterey)

Figure 2-1: Existing FEMA 100-yr and 500-yr Flood Hazards



City of Monterey

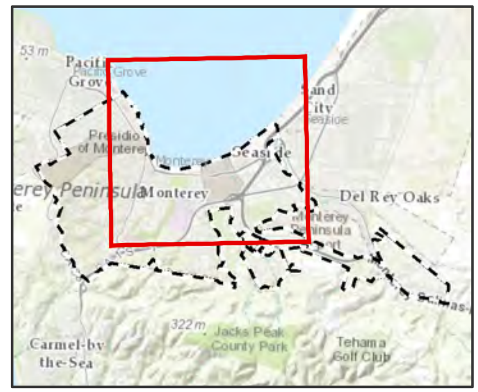
Coastal Zone Boundary

Existing FEMA

100-yr Flood

500-yr Flood

The data utilized for purposes of this Report was collected from various sources and is not to be construed as "legal description." This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.



Revell Coastal Surf. Sand. Sustainability.

City of Monterey California

EMC Planning Group

2.8 Habitats

Within the City of Monterey, there are a wide variety of habitat types ranging from rocky intertidal to Monterey Pine forest and areas that have been altered by development and range from urban to relatively undisturbed. Many of these habitats are considered sensitive and home to several sensitive and endangered species. These habitats and listed species and potential impacts are discussed in the Sector Profile on Biological Resources (Appendix B).

Key Habitats in the City of Monterey include:

- Central Dune Scrub and Coastal Foredune
- Monterey Pine Forest
- Oak Woodland
- Riparian and Wetland Habitats
- Ornamental Landscaping
- Urban Non Vegetated Areas
- Shoreline and Marine Habitats

Environmentally Sensitive Habitat Areas (ESHAs) are defined by the California Coastal Act Section 30107.5 as any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments. These areas are to be protected against significant disruption of habitat quality and only uses consistent with those habitats are allowed. Development near ESHAs are required to be designed to prevent impacts and degradation of the site (Section 30240).

Associated with the sensitive habitat resources, there are 52 potential sensitive species of plants and 34 species of wildlife potentially found in the City of Monterey. For a complete description of the habitats and discussion of the sensitive species, please see Appendix B, Existing Conditions Report: Biological Resources.

As climate change shifts temperature, precipitation, and vegetation ranges, species that previously inhabited these areas may face increasing difficulty in finding suitable habitat. Species with restricted ranges are acutely sensitive to changes in abundance, distribution, and timing of growth or life stages and will require intervention to continue living in these altered biological systems. For marine species, ocean acidification is an additional stressor (California Office of Environmental Health Hazard Assessment 2013).

2.9 Human Alterations to the Shoreline

The shoreline in the City of Monterey has been altered by many different activities. These human alterations have changed the natural functioning of the system. There are several categories of alterations which affect the overall coastline along the City of Monterey which include:

- Harbor construction
- Railroad
- Sand Mining
- Coastal Armoring

Harbor

Beginning in 1870, the Pacific Coast Steamship Company constructed a wharf in Monterey for regular passenger and freight service. Growth of the sardine fishery industry prompted the City of Monterey to acquire the wharf in 1913 and it became known as Fisherman's Wharf. In 1925, increasing commercial fishing demands resulted in construction of Wharf #2 by 1926. The 1700 foot breakwater was constructed in 1934 to improve the navigation safety by reducing the wave energy at both of the wharves. This is the location of the present day Coast Guard Pier. In the 1950's declining fisheries led to a conversion of Fisherman's Wharf to a tourist-oriented operation. By 1960, a small craft marina was constructed with 367 berths. As part of this project a seawall was constructed between Wharf 2 and Fisherman's wharf. The effect of the Harbor and Wharf construction has been to reduce wave energy and coastal hazard vulnerabilities inside the harbor while encouraging coastal dependent recreation and tourism.

Photo 2-4. Monterey Waterfront in 1907 (Photo Monterey Library, California History Room)

Railroad

The railroad used to provide transit between Castroville and Pacific Grove to support military operations at Ford Ord, the canneries along Cannery Row, and a lumber yard in Pacific Grove. Built in 1879 by Southern Pacific Railroad, the rail line ran until 1971. The City of Monterey purchased the right of way (ROW) in 1983 with funding in part from Caltrans and converted it to the existing Recreational trail that runs along the City's waterfront connecting Seaside and Pacific Grove.

Sand Mining

Southern Monterey Bay has been the most intensively mined shoreline in the United States. The sand is valuable due to high silica content, and is used for a variety of purposes including packing for water well casings, filtration, sandblasting, and foundation and surface finishing (Comebellick and Osborne 1977).

Historically, sand mining began in 1906 near the mouth of the Salinas River. In the 1940s, intensive drag line mining extracted sand from the beach itself at 5 different locations. As the sand mining increased, the rate of coastal erosion also increased leading to some of the highest erosion rates in the State of California. (Hapke et al 2006).

Photo 2-5. Drag line sand mining in Sand City (Copyright © 2002-2015 Kenneth & Gabrielle Adelman, California Coastal Records Project)

Between 1986 and 1990, the U.S. Army Corps of Engineers issued regulatory rulings which shut down the drag line sand mining. This was observed to have a noticeable decrease in erosion rates for a short period of time (Thornton 2006). However, the one remaining sand mine in Marina which uses a hydraulic dredging operation increased operations following the shutdown of all of its competitors and the rates of highest erosion have now shifted farther to the north of the City of Marina.

Overall the effect of sand mining to the beaches of the City of Monterey has been to escalate the long-term erosion rates (PWA 2008). Modeling completed in 2010 showed that there would likely be a 70% reduction in erosion rates throughout southern Monterey Bay if the Marina sand mine were to cease operations (PWA 2010). Presently, an enforcement case is pending a decision from the California Coastal Commission.

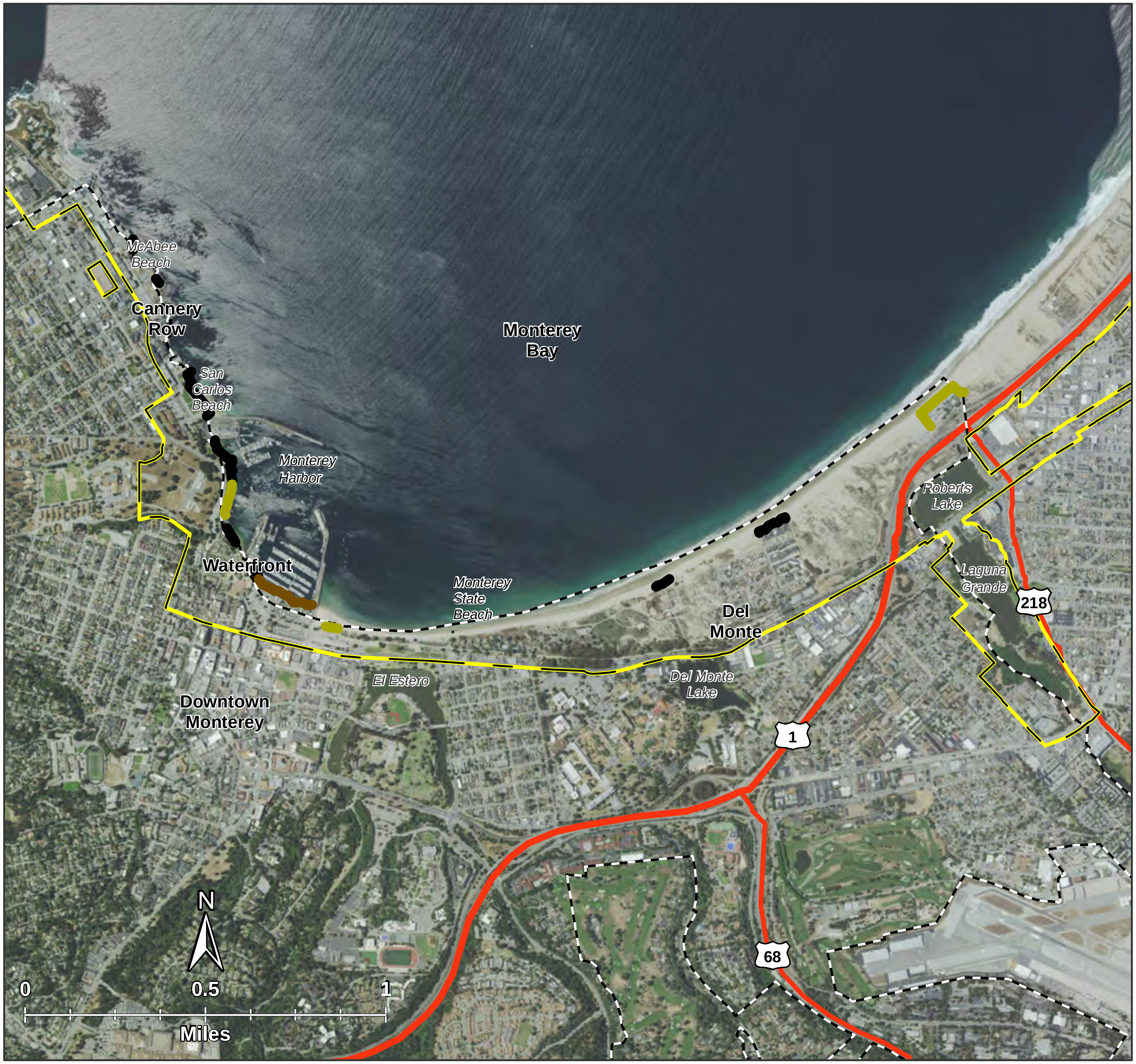
Coastal Armoring

Coastal armoring is relatively sparse across the City of Monterey. Presently there are 7 coastal armoring structures within the City jurisdiction (Figure 2–2). Several of the structures have been built to protect private property, notably the Ocean Harbor House, and the Monterey Beach Hotel as well as some of the hotels and tourist serving facilities along Cannery Row. One of the structures was built to protect the ocean outfall for the Naval Postgraduate School pump station. The remainder of the coastal armoring structures have been constructed to protect the harbor and related infrastructure.

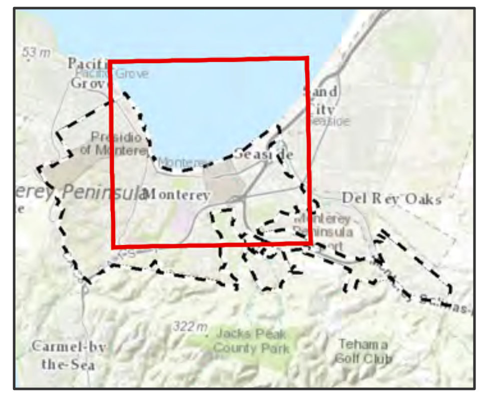
The Municipal Wharf #2 seawall was constructed between 1977 and 1983 to prevent sand from drifting under the wharf and onto the adjacent harbor basin. As a result of this impoundment of sand immediately east of Municipal Wharf #2, the shoreline fronting the plaza has advanced seaward. The shoreline fronting the Sea Scout building has advanced between 100 and 180 feet seaward over a period of 41 years from 1945 through 1986. This is likely a result of the reduced wave energy behind the Monterey Harbor Breakwater.

For many years, the City has maintained an artificial berm fronting Del Monte Beach next to the Sea Scout building during the storm season in the area most susceptible to wave run-up. The Sea Scout building itself also provides significant protection from wave run-up reaching the areas behind the building. The Sea Scout building has been in place for approximately 50 years and appears not to have been damaged from the effects of wave run-up. In addition to the artificial berm and the Sea Scout building, there is a natural small sand dune that provides significant protection for the low-lying areas behind the beach. A low height rock wall is also located on top of the sand dune, most likely placed there by the railroad operators to prevent wave run-up from reaching the tracks in the low lying areas behind the beach. This wall is not structural in design. This wall indicates that the sand dune has most likely been overtopped by waves in the past and at a minimum created a nuisance for the railroad facilities behind the dunes (Skelly Engineering 2000).

Figure 2-2: Coastal Armoring Extents



The data utilized for purposes of this Report was collected from various sources and is not to be construed as "legal description." This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.



REVELL COASTAL
Surf. Sand. Sustainability.
CITY OF Monterey CALIFORNIA
EMC PLANNING GROUP

3. Climate Science

3.1 Climate Cycles

Climate change is not to be confused with climate cycles, which also operate independently of human-induced climate change. Some of these climate cycles occur at long time periods and are related to the orbit of the earth around the sun, the tilt of the earth on its axis, and precession (subtle shift) of the earth's orbit. These Milankovitch cycles occur at approximately 41,000, 120,000, and 400,000 years and are responsible for the Ice Ages observed in the geologic record.

Some of these climate cycles are shorter; the most commonly known cycle is the El Niño/La Niña cycle, which is related to changes in equatorial trade winds and shifts in ocean temperatures across the Pacific Ocean. An El Niño brings warmer water to the Eastern Pacific, and this shift in ocean temperatures elevates sea level rise by about a foot above predicted tides in the Monterey Bay. These warmer ocean temperatures can increase evaporation, resulting in more atmospheric moisture and often substantially more precipitation. The 1982–1983 and 1997–1998 El Niños have caused both river and coastal flood damages across the Monterey County region. The January 1983 wave event is considered to be the largest storm recorded in the Monterey Bay.

Another climate cycle that impacts the Monterey Bay area is the Pacific Decadal Oscillation (PDO), which is an approximately 25–30-year cycle that changes the distribution of sea surface temperatures across the Pacific. Its effects were first noticed by fishery researchers in Washington (Mantua et al. 1997). The result of this ocean temperature shift is largely a shift in the jet stream. During the warm phase, the jet stream changes the storm track toward the south, affecting both the wave direction (increase in wave energy into the Monterey Bay) and precipitation. At present, the index has been on the cool side, which tends to lead to less precipitation in Monterey. One other implication of the PDO is that the rate of sea level rise is reduced in the Eastern Pacific (off the U.S. West Coast). Recent PDO research indicates that a shift in the PDO would likely result in much more rapid rise in sea levels off the U.S. West Coast than has been seen in the last three decades (Bromirski et al. 2011).

3.2 Climate Change

Human-induced climate change is a consequence of increased greenhouse gas emissions from the burning of fossil fuels that accumulate in the atmosphere and insulate the earth from outgoing long-wave radiation. As this atmospheric emissions blanket gets thicker, more heat is trapped in the earth's atmosphere, warming the earth and triggering a series of climate changes related to different feedback mechanisms. Once set in motion, many of the climate change feedbacks take centuries to millennium to stabilize.

Globally, sea levels are rising as a result of two factors related to increasing temperature caused by human-induced climate change. The first factor is the thermal expansion of the oceans. As ocean temperatures warm, the water in the ocean expands and occupies more volume, resulting in a sea level rise. The second factor contributing to eustatic (global) sea level rise is the additional volume of water added to the oceans from the melting of mountain glaciers and ice sheets. It is predicted that if all of the ice were to melt on earth, ocean levels would rise by approximately 220 feet above present-day levels. The rate at which it rises will largely depend on the feedback loop between the melting of the ice, which changes the land cover from a reflective ice surface, and the open ocean water, which absorbs more of the sun's energy and increases the rate of ice melt.

3.3 Climate Projections: Scientific Overview

Substantial research in California is currently underway to effectively downscale climate change models and to project various human-induced climate change impacts at a local scale. By analyzing the outputs of these downscaled models, the City can better understand the range of likely climate impacts specific to Monterey. Several of the key climate change impacts are likely to include increased temperature, uncertainty in precipitation changes, decreased wildfire, and sea level rise.

For each of these impacts, downscaled global climate model results are summarized based on a medium high future emissions scenario ("business as usual") and a medium low scenario ("substantial reduction in global greenhouse gas emissions") to provide a range of future projections specific to Monterey. For more detail on any specific parameter, please see the cited information. New climate model results should be e reviewed and incorporated into the City's vulnerability/adaptation process as appropriate in the future. Climate model results presented below summarize the climate change impacts from statewide-downscaled models funded largely by the California Energy Commission (CEC) completed in 2009 and available publicly from Cal Adapt.

3.4 Climate Impacts

Temperature

Temperature increase, one of the primary impacts of climate change, is caused by the increase in greenhouse gases in the atmosphere, which traps more heat. Temperature changes can cause health risks associated with increases in temperature and number of extreme heat days; which can disproportionally affect vulnerable older and low income populations. Temperatures changes also affect the length of warm period heat waves, increase the length of droughts, and force existing habitats and species to migrate to more suitable, cooler habitats.

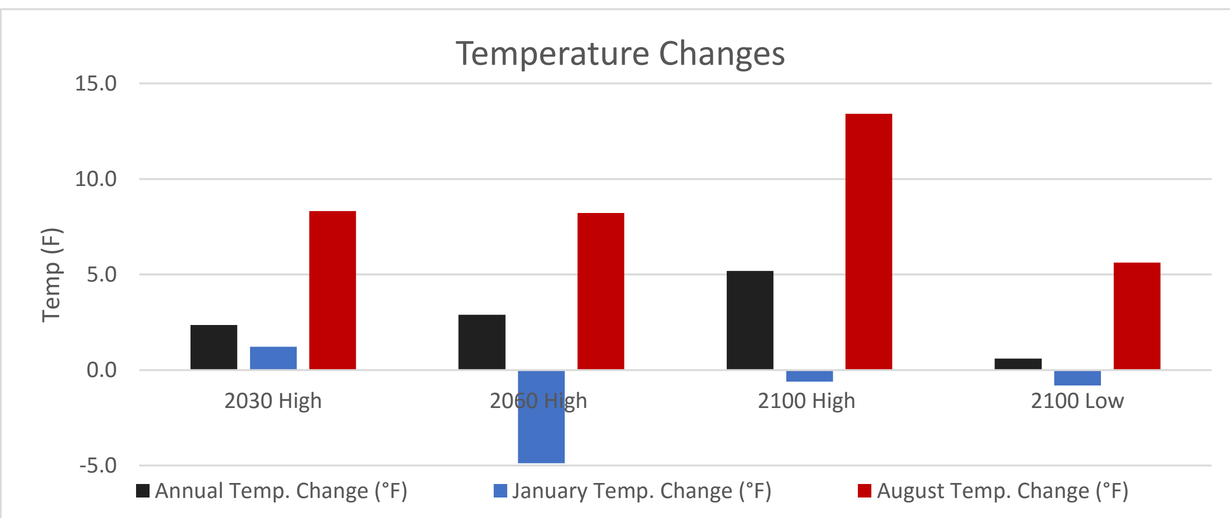


Figure 3-1. Projected Temperature Changes under the high emissions scenario for 2030 and 2060 with projected temperature changes for both a high and low emissions scenario in 2100 for Monterey, CA. Text descriptions below provide the ranges for each planning horizon (Source: Cayan et al. 2009)

Future temperature projections for Monterey show that average annual temperatures are expected to rise by between 0.4° and 2.4°F by 2030, 1.5° and 2.9°F by 2060, and 0.6° and 5.2°F by 2100 (Figure 3-1). The projected increase in temperature in Monterey would not be uniform throughout the year. The wintertime (January) and summertime (August) temperatures are projected to rise and fall at different rates than the average annual changes. January temperatures are projected to decrease over time between -5.9° and (increase) 1.2°F by 2030, -3.3° and -4.9°F by 2060, and -0.8° and -0.6°F by 2100.

In contrast, August temperatures are projected to increase between 2.1° and 3.4°F by 2030, 3.4° and 5.5°F by 2060, and 6.3° and 13.1°F by 2100. In summary, temperature projections show a split in seasonal changes throughout the year with the summer (August) showing the greatest increase up to 13.1°F by 2100 and winter (January) with greatest decrease in 5.9° by 2060. These results show that there is likely to be an increase in overall temperature ranges throughout the year.

Extreme heat in Monterey is defined as a day between April and October that temperatures are above 80°F (Figure 3-2). The historical average for the time period from 1961 to 1990 was 7.5 days between April and October with an average length of the extreme heat waves of 2 days. By 2030, models project between 5 (low scenario) and 9 (high scenario) days per year with the duration of the heat waves unchanged at up to 2 consecutive days a year. By 2060, a projection of extreme heat days ranges from 14 to 22 days between April and October with an estimated increase in the length of heat waves up to 2 consecutive days. By 2100, projections of extreme heat waves increase up to between 19 and 71 days between April and October with further increase in the length of the heat waves up to 16 consecutive days.

The increase in extreme heat days can cause heat related illnesses to young and elderly populations and adversely impact low income populations many of whom work outdoors in the Monterey agricultural industry.

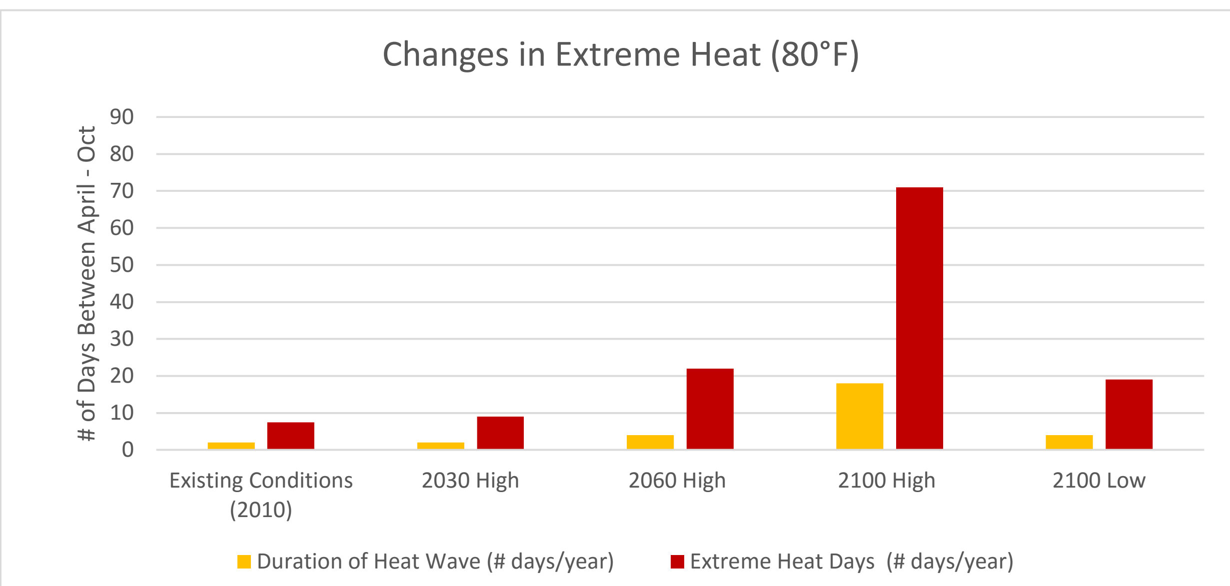


Figure 3-2. Projected Extreme Heat and Duration of Heat Waves (Source: Cayan et al. 2009)

Precipitation and Wildfire

Another climate change impact will likely be to precipitation; the amount of moisture in the atmosphere can either increase or decrease based on the amount of temperature changes affecting evaporation and changes in humidity. Rainfall patterns will change and vary regionally, with winter and spring rainfall in the northern U.S. expected to rise and rainfall in the Southwest, including California, to decrease, particularly in the spring. Even as overall precipitation in the Southwest is projected to decrease, the number of heavy rainfall events is anticipated to increase (Walsh et al. 2014).

Precipitation and temperature also affect the wildfire risk. Increased precipitation increases plant growth, thereby adding more fuel, and increases in extreme heat can reduce vegetative growth (Figure 3-3). Changes in precipitation are relative to time period averages between 1961 and 1990, while changes in wildfire risk are relative to existing conditions (2010).

However, the precipitation variable (and thus the changes in wildfires that are dependent on precipitation) is one of the least certain of the climate change impacts. To accommodate this uncertainty, decadal averages of precipitation from modelling results were used in the analysis. Models vary widely, and this is an area of active research. Results in this section come from modeling completed in 2009. Ongoing research at Scripps Institute of Oceanography continue to investigate these two climate change variables.

Based on the modeling completed and publicly available from 2009, under the high emissions scenarios, precipitation in Monterey is projected to experience a long-term decrease through 2100. By 2030, the precipitation projections are relatively unchanged with an increase by 2.0 percent. By 2060, precipitation is projected to range between a decline of 13.0 percent and increase 9.0 percent. By 2100, the precipitation is projected to range between decrease of 30 percent and increase 24 percent depending on which emissions scenario actually occurs.

In general, under the high emissions scenario the pattern is for declining amounts of annual precipitation, longer droughts, and more extreme events.

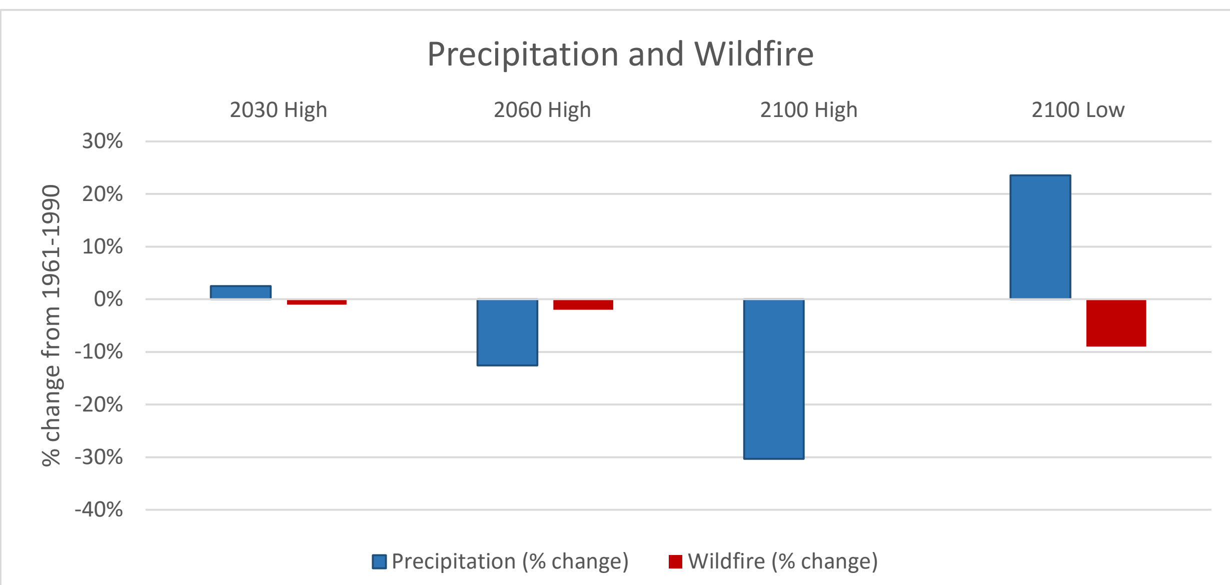


Figure 3-3. Projected Changes in Precipitation and Wildfire (Source: Cayan et al. 2009)

A positive climate change projection is that wildfires in Monterey Area are projected to relatively unchanged from the 2010 levels. By 2030, wildfire is projected to decrease about 1 percent. By 2060, the wildfires are projected to decline between 1 and 2 percent, and finally by 2100 the wildfires are projected to decline up to 9.0 percent. With overall pattern of decline in precipitation and relative unchanged in wildfire frequency is likely to reduce the amount of vegetative growth, which reduces the fuel load available for wildfires.

Sea Level Rise

Sea level rise can increase flood risks in low-lying coastal areas and areas bordering rivers. A 5-foot increase in water levels caused by sea level rise, storms, and tides is estimated to affect 499,822 people, 644,143 acres, 209,737 homes, and $105.2 billion of property value in California coastal areas (Climate Central 2014).

The time scales for sea level rise are related to complex interactions between the atmosphere and the oceans and the lag times associated with the stabilization of greenhouse gases in the atmosphere with the dissolution of those gases into the ocean. The Intergovernmental Panel on Climate Change (IPCC) has published scientific evidence that demonstrates that, due to the greenhouse gases already released into the atmosphere, the sea levels will be rising for the next several thousand years. Given this long-term perspective, it is not a question of if sea level rise will happen, but when it will happen.

Relative Sea Level Rise

Sea level rise is not the same everywhere around the world. Because of local differences in tectonic uplift; subsidence caused by oil, gas, and groundwater extraction; and saltwater intrusion, the land itself is moving vertically. The difference between the local land motion and the global rise of sea level gives the relative sea level rise that will determine the magnitude of local sea level rise impacts. The Monterey Tide Gage, which reports the local sea level rise rate at a rate of approximately 1.16 (+/-0.95) millimeters per year, has a sporadic historical record (Figure 3-4). Since the tide gage was installed in the mid-1970s, the relatively short time period of record leaves high range in the confidence intervals for the relative sea level rise calculations from the tide gage.

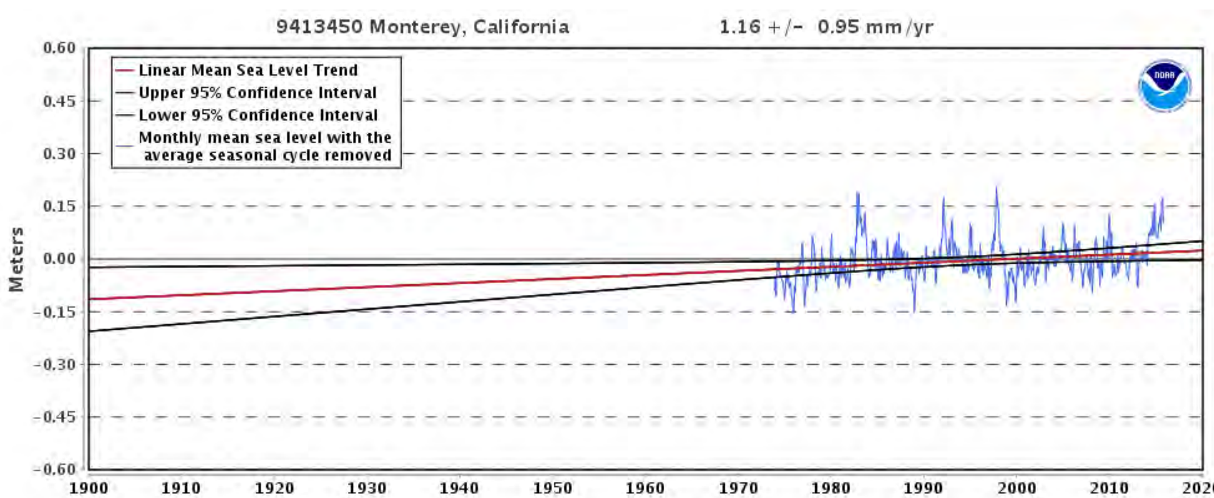


Figure 3-4. Tide Record and Sea Level Rise Trend from Monterey Tide Gage (NOAA Station 9413450)

Sea level rise scenarios used in this analysis were selected consistent with the CCC's 2015 Sea Level Rise Policy Guidance (CCC 2015) and consistent with the science published by the National Research Council (NRC 2012) for areas south of Cape Mendocino (where the faulting and vertical land motion change) (Table 3-1).

Thus, Monterey can expect between 1.1 and 8.8 inches of sea level rise by 2030, between 6.3 and 28.3 inches by 2060, and between 16.1 and 62.6 inches by 2100 (Table 3-1).

Table 3-1. Sea Level Rise Scenarios by Planning Horizon (adapted from NRC 2012 & ESA 2014)

Year	Low SLR	Medium SLR	High SLR*
2030	1.1 inches	4.0 inches	8.8 inches
2060	6.3 inches	12.8 inches	28.3 inches
2100	16.1 inches	34.5 inches	62.6 inches

3.5 Other Regional Scientific Initiatives

Currently, there are a wide variety of scientific investigations studying and modeling the impacts of coastal hazards, climate change, and adaptation economics for the Monterey region. The studies discussed below demonstrate the most promise and focused applicability to the City of Monterey.

2008 Coastal Regional Sediment Management Plan for Southern Monterey Bay

In 2008, Philip Williams and Associates completed a Coastal Regional Sediment Management Plan, which identified what is known about sand supplied to the coast between Wharf 2 in Monterey and the Monterey Submarine Canyon, including new understanding of the sediment budget, causes of erosion hot spots, the impact of sand mining, and shoreline armoring. Recommendations from this plan include new ways to manage sediment, including development of an opportunistic sand placement program, sand rights policies, and changes in regional governance structure, which would support better use of coastal sediments.

2010 Technical Evaluation of Erosion Mitigation Alternatives (PWA)

Between 2008 and 2010, Philip Williams and Associates working with the Southern Monterey Bay Coastal Erosion Working Group and the Monterey Bay National Marine Sanctuary conducted a study evaluating potential erosion mitigation alternatives. This project took a holistic approach looking at both the engineering feasibility, the technical effectiveness, and the net economic benefits to over 20 different erosion mitigation strategies (aka adaptation strategies). Key findings were to stop sand mining and avoid coastal armoring to maximize the long term economic benefits to the region. While the study did not directly include sea level rise, this study led the way to the 2014 Monterey Bay Sea Level Rise Vulnerability Study, and the 2016 Adapt Monterey Bay studies.

2014 Monterey Bay Sea Level Rise Vulnerability Study (ESA)

This modeling effort projects the impacts of coastal erosion and coastal flooding for the Monterey Bay, extending from Año Nuevo Point to Wharf 2 in Monterey. A technical methods report presents technical documentation of the methods used to map erosion and coastal flood hazards under various future climate scenarios. The climate-change–exacerbated coastal hazard modeling considered different scenarios of sea level rise, wave climate, and sand mining. This study and model outputs provide much of the hazard identification used in support of the City's vulnerability assessment.

2016 Adapt Southern Monterey Bay

This study is an update to the economic and physical analysis conducted in the 2010 Technical Evaluation of Erosion Mitigation Alternatives. The overall project evaluates a range of adaptation strategies and compares the benefits of having a beach versus protecting upland property. The approach includes improved coastal hazard modeling resulting from implementation of various adaptation strategies and improved economic analysis that includes accounting for the value of storm damage reduction to upland properties, recreational benefits, and ecosystem services. Final report is due out in Spring of 2016.

2015 The Nature Conservancy's Coastal Resiliency Mapping Tool

The Coastal Resiliency Mapping Tool by The Nature Conservancy has been developed for geographies around the world to visualize the extent and magnitude of sea level rise and coastal hazards. The web mapping application provides an interactive visualization tool. (maps.coastalresilience.org/California) This tool allows users to explore the risks of different scenarios of coastal hazards—such as sea level rise, storm surges, and inland flooding—at a variety of spatial scales.

2016 Monterey and Santa Cruz County Vulnerability Assessment

Consistent with the CCC's emphasis on crafting regional approaches to sea level rise, and funded by the Ocean Protection Council to Monterey County, this project is evaluating future vulnerabilities to sea level rise to Santa Cruz and Monterey County. The project includes improved coastal confluence modeling of Soquel Creek (Capitola), and the old Salinas River (Moss Landing). Focus areas of interest are Capitola and Moss Landing. Projected completion is end of 2016.

2016 FEMA Pacific Coastal Flood Mapping

FEMA is currently updating the Pacific Coastal flood maps for FEMA Region IX. The California Coastal Analysis and Mapping Project is conducting updates to the coastal flood hazard mapping with best improved science, coastal engineering, and regional understanding. The project incorporates regional wave transformation modeling and new run-up methods and will be revising the effective flood insurance rate maps for coastal flood hazard zones. This will include revised VE (wave velocity), AE (ponded water), and X (minimal flooding) zones. The anticipated completion date is 2018.

4. Sector Vulnerabilities

4.1 Introduction

This report used several primary data sources:

- Coastal hazards modeling analysis results (ESA 2014).
- FEMA effective flood maps (FEMA 2012).
- Revised cliff erosion distances (see section 4.2
- Spatial and locational data available from the City of Monterey, Association of Monterey Bay Area Governments, Environmental Systems Research Institute (ESRI), and The Nature Conservancy (TNC 2015) (and Figure 4-1).

Projections of future climate change impacts came from a variety of sources including: Cal Adapt, and Scripps Institution of Oceanography.

Projections of future coastal hazards and sea level rise were modeled as part of a separate project completed during the Monterey Bay Sea Level Rise Vulnerability Assessment (ESA 2014). Substantial research in California is currently underway to effectively downscale climate change models and to project various human-induced climate change impacts at a local scale.

4.2 Vulnerability Assessment Methodology

The vulnerability assessment involved spatial analysis on a wide variety of data provided by the City GIS staff, Revell Coastal, and/or EMC Planning. After working with the City and Coastal Commission staff to identify the appropriate sectors and measures of impact, the geospatial analysis was conducted in the ArcGIS environment. For each sector and measure of impact, the respective data set was queried, summary statistics calculated by planning horizon (or sea level rise elevation) and by each type of coastal hazard. Vulnerability was determined by intersection of the various coastal hazard types (see below) with the various sectors. Results were collated into a master vulnerability table with the results interpreted into the sector vulnerability profiles found in Appendix A.

Coastal Hazard Modeling

The modeling work for the 2014 Monterey Bay Sea Level Rise Vulnerability Assessment Project included modeling of the following coastal processes:

- **Coastal King Tide Flooding:** Based on an expected monthly recurrence.
- **Coastal Flooding:** Flooding caused by waves, including run-up, overtopping and filling of low lying areas.

- **Short-Term Coastal Erosion:** Short-term coastal erosion based on a 1 percent annual chance storm wave event.
- **Long-Term Coastal Erosion:** Long-term coastal changes caused by erosion related to sea level rise and historic trends in erosion.

Coastal Erosion

Erosion was modeled for the respective backshore types—dune-backed or cliff-backed shorelines.

Dune Erosion. The coastal dune erosion hazard modeling considered a short-term response based on the erosion from a 100-year storm wave event. For long-term dune erosion, two components—erosion from sea level rise and erosion caused by historic trends in shoreline change (as a proxy for sediment supply)—were combined and mapped separately. In modeling for both types of dune erosion, inland extents were projected using a geometric model of dune erosion originally proposed by Komar et al. (1999) and applied with different slopes to make the model more applicable to sea level rise (Revell et al. 2011). This method is consistent with the FEMA Pacific Coast Flood Guidelines for storm-induced erosion (FEMA 2005).

Cliff Erosion. Cliff erosion hazard zones were projected using a model that accelerates historic erosion rates based on the increase in sea level rise. For historic erosion rates, the study relied on rates published by other authors (see Section 2.6 for detail). In addition, an erosion factor of safety was included representing the maximum width of a cliff failure in the Monterey Peninsula granite and applied at the end of each planning horizon.

Coastal Storm Flooding

The coastal storm flood modeling was consistent with FEMA's Pacific Coastal Flood Guidelines (FEMA 2005). The high tide coastal storm flood modeling was integrated with the coastal erosion hazard zones. Every 10 years, erosion projections were made and the coastal storm flood model considered areas that were eroded during this time period and thus exposed to wave flooding through enhanced hydraulic connectivity. For the coastal storm flooding, the storm of record was used—a large historic storm event that occurred during 18 years of wave buoy data available at the time of the study.

Coastal Flooding

Wave induced coastal flood modeling assessed the inland extent of wave velocity and inland extents of flooding using the method of Hunt (1959) and supported in the Shore Protection Manual (USACE 1984). This method calculated the dynamic water surface profile, the nearshore depth limited wave, the wave run-up elevation, and inland extent at the end of each representative profile. This hazard represents a future FEMA velocity wave impact zone (a.k.a. V-Zone).

Wave Overtopping

Wave overtopping modeled the flooding associated with a volume of water overtopping of structures or low lying backshore. The volume then filled basins (e.g. Esteros) based on the relationship between the existing elevation and storage volume. This hazard represents the FEMA ponded water flooding (AE) hazard zone. The coastal flood hazard zones have combined both of these coastal flooding processes into a singular overall extent.

Coastal Inundation

Tidal inundation modeling represents the Extreme Monthly High Water level (EMHW) or what areas are projected to get wet once a month. This modeling is similar to a king tide. This monthly elevation was averaged from maximum monthly water levels at the Monterey Tide Gage (EMHW = 6.5 feet NAVD88) and then applied to each of the sea level rise scenarios. In Monterey, it is assumed that the existing wharf breakwaters, and other navigational protections will be maintained sufficiently to protect the inner harbor from breaking wave conditions.

Aggregated Hazards

For each planning horizon, projected hazards were combined into a single layer using a process called "spatial aggregation" (ESA PWA 2012). This layer represents the overlap in all of the hazard zones and shows how many of the various sea level rise and wave condition scenarios impact specific areas. For example, an area mapped under three scenarios indicates that the area was hazardous during that planning horizon for all scenarios.

The localized coastal hazard modeling methodology relies on a detailed parcel-level backshore characterization that includes backshore type, geology, and local geomorphology (i.e., elevations, beach slopes). The backshore characterization was analyzed at approximate 100-yard spacing and then statistically represented at an approximate 500-yard alongshore distance. Calculations of wave run-up and tides are combined into a total water level elevation, which then drives coastal erosion and shoreline response models (Heberger et al. 2009, Revell et al. 2011). Climate change impacts—assessed using a series of sea level rise, wave climate, and precipitation scenarios—projected potential future coastal erosion and flooding hazards (ESA PWA 2013). Projected impacts were evaluated at four planning horizons: existing (2010), 2030, 2060, and 2100. All hazards were mapped on the California Coastal LIDAR Digital Elevation model (available from the NOAA Digital Coast website).

Combined Hazards

To generate the maps shown in the sector profiles, the coastal flooding, dune and cliff erosion and tidal inundation were combined into a single data layer representing the maximum combined extents of all of the hazards. This combined hazard layer was generated to provide a mapped depiction of this mapped extents. Results of the vulnerability analysis were conducted using the individual hazard types described above and summarized in the sector profiles.

4.3 Modeling Assumptions

As with all modeling, assumptions had to be made to complete the work. Below are some of the more important modeling assumptions made in the ESA PWA 2014 work.

Coastal Erosion and Flood Hazard Projections Do Not Consider Existing Coastal Armoring

The coastal hazard projections did not consider the influence of existing water outfall structures and coastal armoring on changes to coastal erosion and coastal flood hazard projections. Instead the coastal erosion hazards show the potential erosion distance without armoring. This assumption may increase the overall mapped extents of the flood and erosion hazards.

Projections of Potential Erosion Do Not Account for Uncertainties in the Duration of a Future Storm

The erosion projections assume that the coast would respond to the combination of high tides and large waves inducing wave run-up. Instead of predicting future storm-specific characteristics (waves, tides, and duration), the potential erosion projection assumes that the coast would erode under a maximum high tide and storm wave event with undefined duration. This assumption likely increases the extent of coastal erosion assuming that over time there is enough wave energy to erode the coast to a new equilibrium location based on storm induced coastal water levels.

Modeling Does Not Consider Future Changes to Precipitation and Runoff from the Watersheds with the Joint Occurrence of Coastal Flooding

Coastal confluence flood modeling has not been completed for the City, so the influence of changes in precipitation and higher water levels from sea level rise on the overall extent of river and stormwater flooding has not been analyzed. This assumption may under predict the overall extent of coastal and fluvial flood sources.

Mapping of the flood hazards used geomorphic interpretation of 2010 topography as existing conditions.

For purposes of analysis, the City's General Plan/Coastal Land Use Plan land uses were categorized into five typical land use types for ease of communicating climate-induced impacts and related vulnerabilities: 1) residential, 2) industrial, 3) commercial, 4) visitor serving accommodations, and 5) open space.

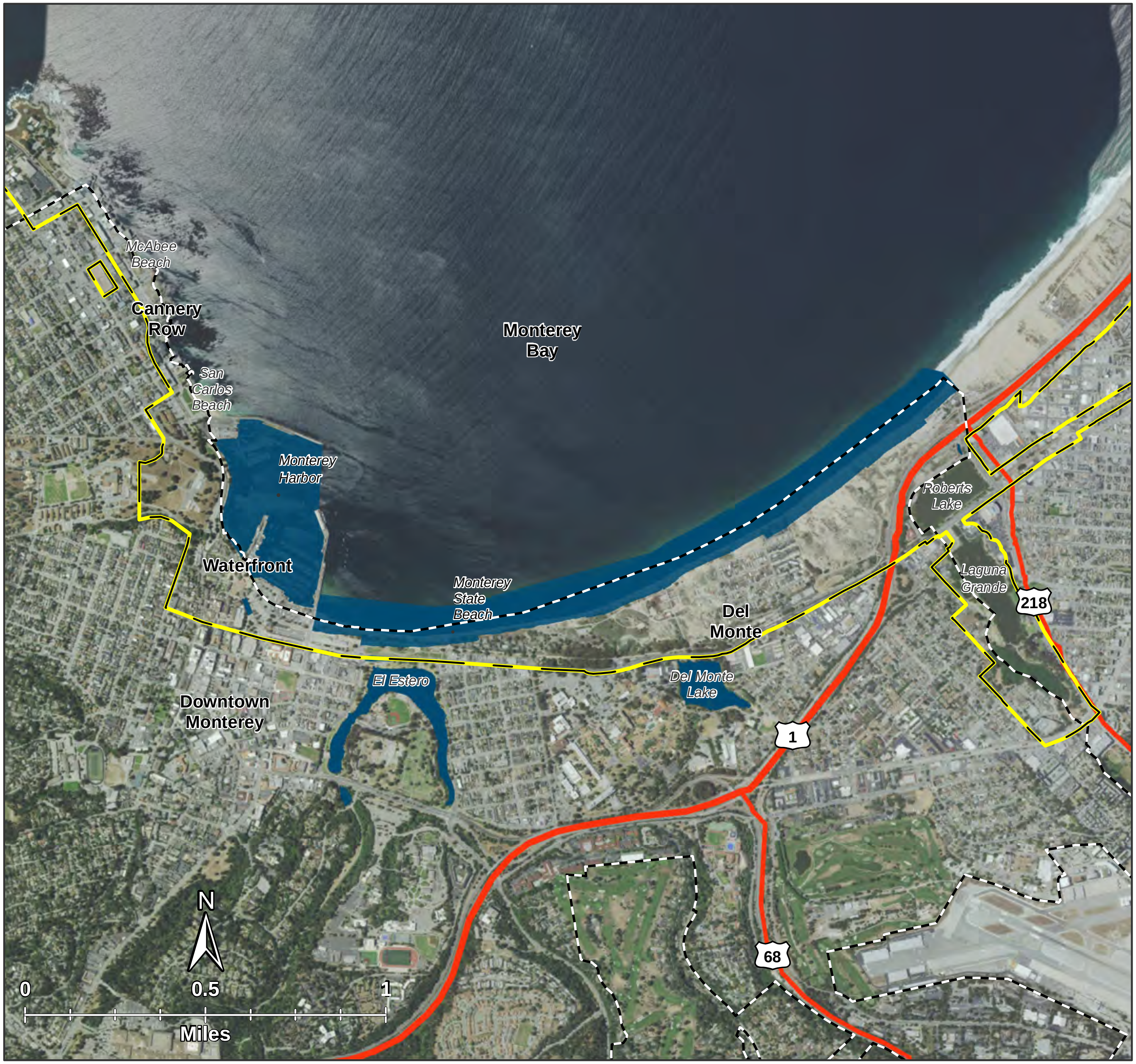
4.4 Vulnerability Results

The combination of the Executive Summary and Appendix A. are intended to provide the results of the vulnerability analysis with a focus on being succinct in summarizing the key findings and locations for the vulnerable sectors across the City.

The key findings for each impacted sector are summarized by planning horizon in the executive summary. The results of the vulnerability assessment for each sector are found in Appendix A.

The sector profiles in Appendix A include an 11x17 double sided page with the first side including a map of each sectors impacts color coded by the timing of impact. On the other side of the sector profiles is a summary of the specific vulnerabilities, by both hazard type and planning horizon including a discussion of the existing conditions, key findings and recommendations.

Figure 4-1: Existing Coastal Hazards



City of Monterey

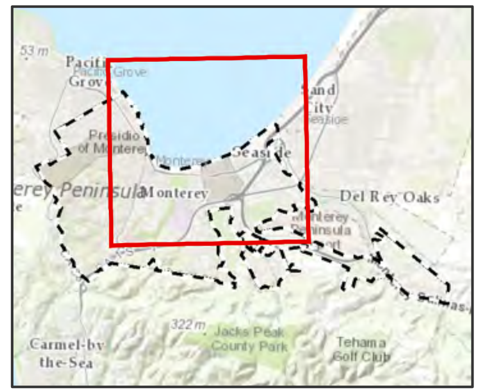
Coastal Zone Boundary

Coastal Hazard Zones

Existing

Hazard Modeling by ESA 2015

The data utilized for purposes of this Report was collected from various sources and is not to be construed as "legal description." This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.



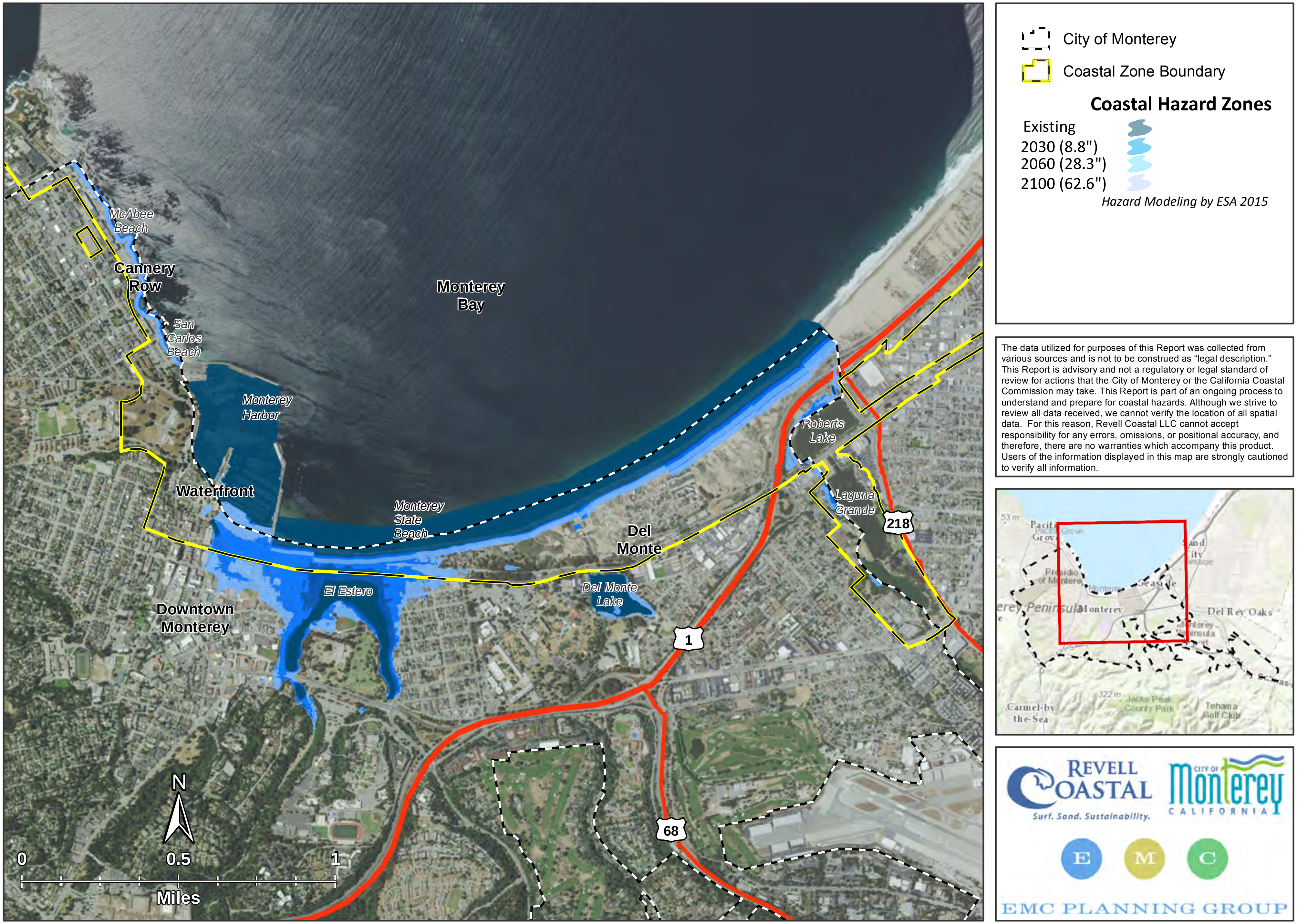
REVELL COASTAL

Surf. Sand. Sustainability.

CITY OF Monterey CALIFORNIA

EMC PLANNING GROUP

Figure 4-2: Existing and Future Coastal Hazards



The data utilized for purposes of this Report was collected from various sources and is not to be construed as "legal description." This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.

5. Preparers

This report was prepared by the following individuals:

Revell Coastal, LLC

- David L. Revell, PhD, Project Director
- Brian Spear, M.S.
- Chandra Slaven, AICP

City of Monterey

- Kim Cole, Planning Director. Planning, Engineering & Environmental Compliance (PEEC) Division
- Elizabeth Caraker, Planner

EMC Planning

- Polaris Kinison Brown
- Andrea Edwards
- Stefanie Krantz
- Michael Groves

.

6. References

Bromirski, P.D., A.J Miller, R. E. Flick, and G. Auad 2011. Dynamical suppression of sea level rise along the Pacific coast of North America: Indications for imminent acceleration. *Journal of Geophysical Research*, Vol. 116, C07005, doi:10.1029/2010JC006759, 2011

California Coastal Commission (CCC 2015). Final Sea Level Rise Policy Guidance. San Francisco, CA. Adopted August 12, 2015. Available: http://www.coastal.ca.gov/climate/slrguidance.html

California Office of Environmental Health Hazard Assessment. 2013. Indicators of Climate Change in California. Available: http://oehha.ca.gov/multimedia/epic/pdf/ClimateChangeIndicatorsReport2013.pdf

Cayan, D, Tyree, M, Dettinger, M, Hidalgo, H. Das, T., Maurer, E, Bromisrksi, P Graham, N, Flick, R. 2009. Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment. CEC-500-2009-014-F Available: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-014-F

City of Los Angeles. 2004. Guide to Resolving Environmental and Legal Issues at Abandoned and Underutilized Gas Stations.

Climate Central. 2014. Surging Seas Available: http://sealevel.climatecentral.org/ssrf/california

Combellick, R.A., Osborne, R.H., 1977. Sources and petrology of beach sands from southern Monterey Bay, California. J. Sediment. Petrol. 47 (2), 981±987.

Cooper, W.S. 1967. Coastal Dunes of California. Memoir 104 of the Geological Society of America. 131pp.

ESA 2014. Southern Monterey Bay Coastal Hazard Modeling and Vulnerability Assessment – Technical Methods Report. Prepared for Santa Barbara County. March 2014.

ESA-PWA. 2012. Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay, Report prepared for the Monterey Bay Sanctuary Foundation and the Southern Monterey Bay Coastal Erosion Working Group. May 2012. Available: http://montereybay.noaa.gov/research/techreports/tresapwa2012.html.

Federal Emergency Management Authority (FEMA). 2005. Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States. Oakland, CA. Prepared for the U.S. Department of Homeland Security. Available: http://www.fema.gov/media-library-data/840f98e4cb236997e2bc6771f04c9dcb/Final+Draft+Guidelines+for+Coastal+Flood+Hazard+Analysis+and+Mapping+for+the+Pacific+Coast+of+the+United+States.pdf .

———. 2009. FEMA Effective Flood Insurance Rate Maps and Flood Insurance Study for the City of Monterey. (Maps #06053C0307G,

#06053C0326G, #06053C0328G, #06053C0309G, and #06053C0306G). Effective date 4/2/2009.

Greene, H.G., Lee, W.H.K., Mc Culloch, D.S., and Brabb, E.E., 1973. Faults and Earthquakes in the Monterey Bay region, California: U.S. Geol. Survey Misc. Field Studies Map MF-518.

Greene, H.G. 1977. Geology of the Monterey Bay Region. USGS Open File Report 77-718. 347 pages

Griggs, G. and L. Savoy 1985. Living with the California Coast. ISBN 0-520-24445-1

Hapke, C., D. Reid, D. Richmond, P. Ruggiero, and J. List 2006. National Assessment of Shoreline Change, Part 3: Historical Shoreline Change and Associated Land Loss Along Sandy Shorelines of the California Coast. Santa Cruz, California: U.S. Geological Survey Open-file Report 2006-1219, 79p.

Hapke, C. and D. Reid 2007. National Assessment of Shoreline Change, Part 4: Historical Coastal Cliff Retreat along the California Coast. Santa Cruz, California: U.S. Geological Survey Open-file Report 2007-1133, 57p.

Heberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. California Climate Change Center. Available: http://pacinst.org/wp-content/uploads/sites/21/2014/04/sea-level-rise.pdf

Hunt, I. 1959. Design of Seawalls and Breakwaters. *Journal of Waterways and Harbors Division*, Proceedings of the American Society of Civil Engineers. Vol 85, No. WW3, Part 1, September 1959, pp. 123-152.

Komar, P.D., W.G. McDougal, J.J. Marra, and P. Ruggiero, (1999). The rational analysis of setback distances: applications to the Oregon Coast. Shore and Beach 67(1):41-49.

Kennedy/Jenks Consultants. 2010 Urban Water Management Plan Update. Prepared for for Monterey Water District. Available: http://www.Montereywater.com/assets/GWD_2010UWMP_Final.pdf

King, P., A. McGregor and J. Whittet. 2015. Can California Coastal Managers Plan for Sea-Level Rise in a Cost-Effective Way. *Journal of Environmental Planning and Management.*

Mantua, N.J. and S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis 1997: A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. Bulletin of the American Meteorological Society, 78, pp. 1069-1079.

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Prepublication. National Academy Press: Washington, D. C.

Revell, D.L., R.Battalio, B. Spear, P. Ruggiero, and J. Vandever, (2011). A Methodology for Predicting Future Coastal Hazards due to Sea-Level Rise on the California Coast. Climatic Change 109:S251-S276. DOI 10.1007/s10584-011-0315-2.

Storlazzi, C.D. and M.E. Field 2000. Sediment distribution and transport along a rocky, embayed coast: Monterey Peninsula and Carmel Bay, California. Marine Geology 170 (200) 289-316.

U.S. Army Corps of Engineers (USACE). 1984. Shore Protection Manual, Volume 2. pp 7-35 to 7-43.

Westerling, A. L., Bryant, B. P., 2008. Climate Change and Wildfire in California. Climatic Change (2008) 87 (Suppl 1): s231-s249

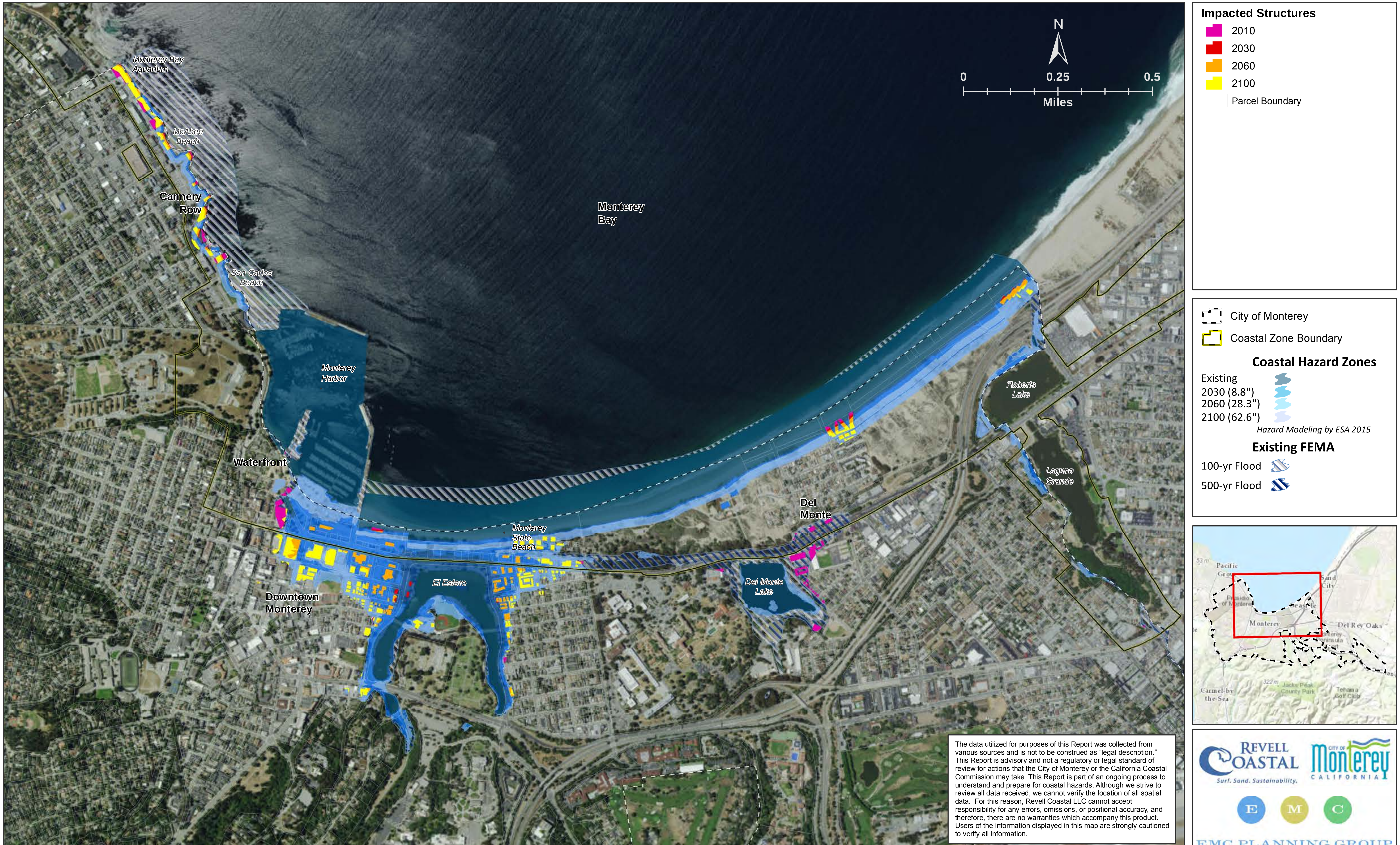
Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, et al. 2014. Our changing climate. *In* Climate Change Impacts in the United States: The Third National Climate Assessment (J.M. Melillo, T.C. Richmond, and G.W. Yohe, eds.), pp. 19-67 (Chapter 2). U.S. Global Change Research Program, Washington, D.C

Appendix A. Sector Profile Results

This appendix contains sector profiles that summarize the findings and recommendations that can be used in future decision-making. Each sector has its own profile, complete with a vulnerability map and 2-page description of findings for ease of communication. They are as follows:

- Land Use and Structures
- Roads and Parking
- Public Transportation
- Wastewater
- Water Supply
- Storm Water
- Hazardous Materials
- Public Access
- Emergency Services
- Public and Military Facilities
- Biological Resources

Land Use and Structures



Land Use and Structures

Overview

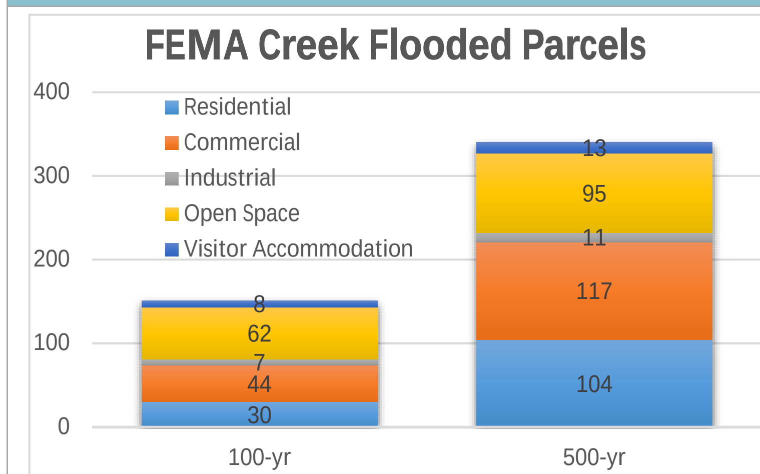
There are **14** land use categories within the City of Monterey, which were categorized into **five (5)** distinct land use types for ease of communication of impacts and vulnerabilities. Land uses were categorized into (1) residential, (2) industrial, (3) commercial, (4) visitor serving accommodation, and (5) open space.

No industrial parcels are impacted by coastal hazards with up to 5 feet of sea level rise.

The following measures of impacts were identified to quantify the impact of coastal hazards and climate change on land use and structures:

- Parcels by land use type;
- Acres by land use; and
- Number of structures and square footage.

Existing FEMA Fluvial flooding



FEMA maps fluvial and coastal hazards as part of the National Flood Insurance program. Flood insurance rate maps are a regulatory product used to set insurance rates. The maps show the extents of a 1 percent (100 year) and 0.02 percent (500 year) creek flooding event and were used to calculate the number of parcels impacted (figure to the left).

<u>**Acres / Number of structures by land use (100 yr. – 500 yr.)**</u>

Residential = 12-18 acres / 15-43 structures
Open Space = 118-164 acres / 36-52 structures
Commercial = 8-21 acres / 29-89 structures
Industrial = 5-5 acres / 0 - 0 structures
Visitor Accommodation = 4-8 acres / 12-18 structures

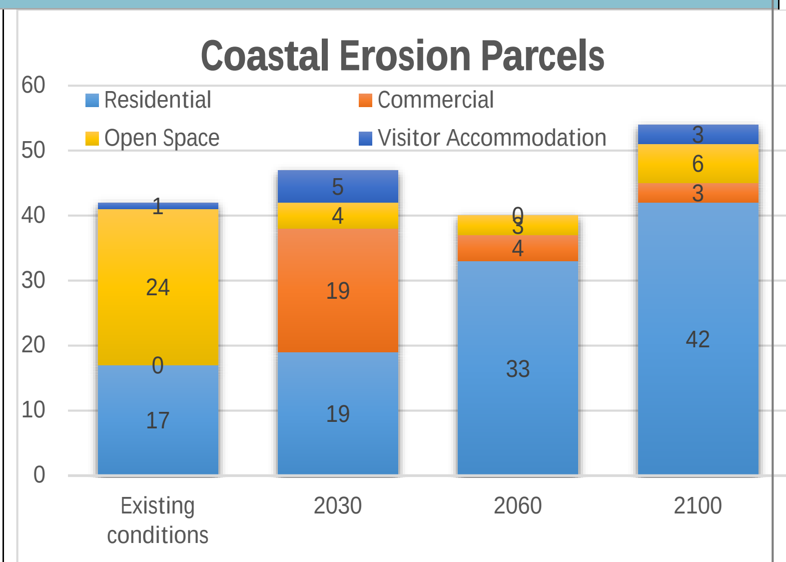
Coastal Erosion

<u>**Existing Conditions**</u>
Residential = 17 parcels / 4 structures
Open Space = 24 parcels / 3 structures
Visitor Accommodation = 1 parcel / 0 structures

<u>**2030**</u>
Residential = 19 parcels / 4 structures
Open Space = 4 parcels / 3 structures
Commercial = 19 parcels / 8 structures
Visitor Accommodation = 5 parcels / 8 structures

<u>**2060**</u>
Residential = 33 parcels / 5 structures
Open Space = 3 parcels / 3 structures
Commercial = 4 parcels / 9 structures
Visitor Accommodation = 0 parcels / 0 structures

<u>**2100 (cumulative through 2100)**</u>
Residential = 111 parcels / 13 structures
Open Space = 37 parcels / 3 structures
Commercial = 26 parcels / 12 structures
Visitor Accommodation = 9 parcels / 11 structures



Coastal erosion impacts open space and residential properties under existing conditions primarily. By 2030, commercial, and visitor accommodations are primarily impacted. Residential vulnerabilities escalate between 2060 and 2100.

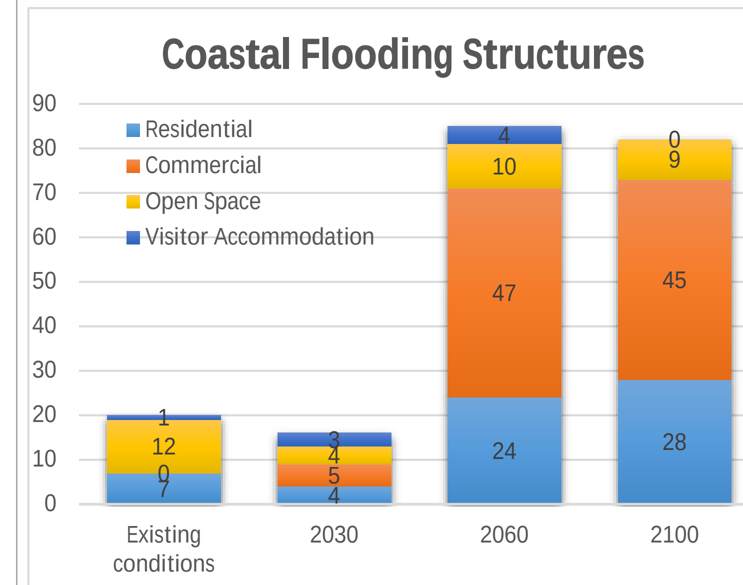
Coastal Flooding

<u>**Existing Conditions**</u>
Residential = 83 parcels / 2 acres
Open Space = 25 parcels / 45 acres
Visitor Accommodation = 1 parcels / 1.2 acres

<u>**2030**</u>
Residential = 19 parcels / 1 acre
Open Space = 14 parcels / 14 acres
Commercial = 10 parcels / 1acres
Visitor Accommodation = 1 parcel / 0.5 acre

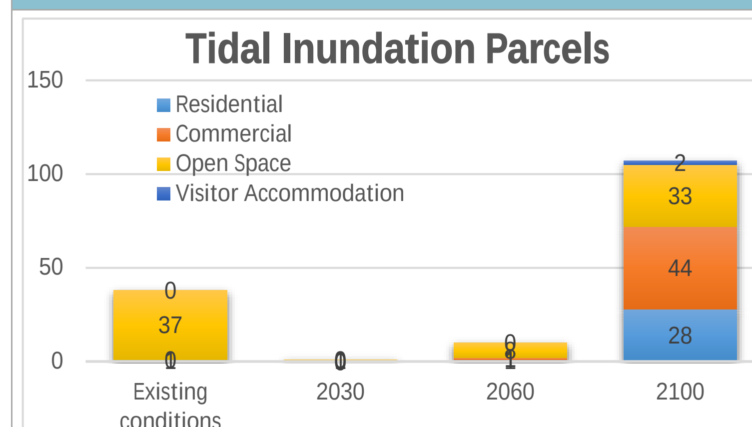
<u>**2060**</u>
Residential = 30 parcels / 3 acres
Open Space = 25 parcels / 24 acres
Commercial = 57 parcels / 9acres
Visitor Accommodation = 2 parcels / 2 acres

<u>**2100 (cumulative through 2100)**</u>
Residential = 191 parcels / 12 acres
Open Space = 78 parcels / 114 acres
Commercial = 107 parcels / 17 acres
Visitor Accommodation = 5 parcels / 6 acres



Coastal flooding impacts open space primarily under existing conditions, then in 2030 minor escalation of vulnerabilities, then in 2060 and 2100 both the commercial and residential sectors increase substantially.

Tidal Inundation



<u>**Existing Conditions**</u>
Residential = 4 structures
Open Space = 10 structures

<u>**2030**</u>
Visitor Accommodation = 1 structure

<u>**2060 -**</u> No additional structures in any land use type at risk

<u>**2100 (totals through 2100)**</u>
Residential = 30 structures
Open Space = 79 structures
Commercial = 44 structures
Visitor Accommodation = 2 structures

Additional Information

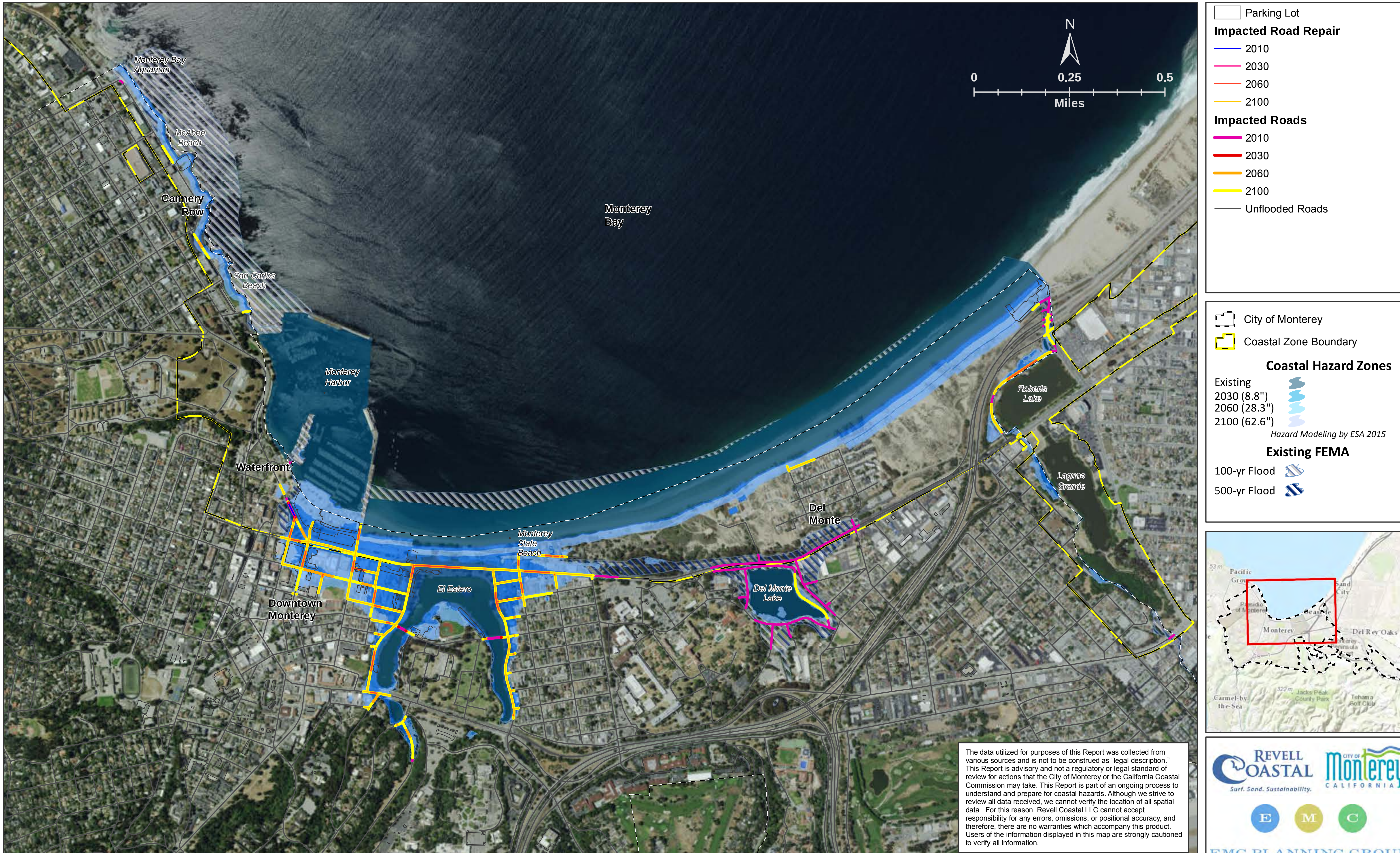
Findings

- Coastal hazards with sea level rise cause more vulnerabilities than fluvial flooding in existing conditions.
- No industrial impacts even with 5 feet of SLR sea level rise.
- Data gap - future creek flood extents exacerbated by changes in precipitation and elevated ocean water levels.
- Tidal inundation hazards reach a threshold of impacts with 5 feet of sea level rise.

Recommendations

- Consider movable foundations and elevated building heights in low-lying areas.
- Strengthen policies prohibiting new coastal armoring.
- Require any abandonment or retreat to remove derelict or threatened structures.
- Evaluate economic damages to provide a basis for evaluating adaptation strategies.

Roads and Parking



The data utilized for purposes of this Report was collected from various sources and is not to be construed as "legal description." This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.

REVELL COASTAL
Surf. Sand. Sustainability.
CITY OF Monterey CALIFORNIA
E M C
EMC PLANNING GROUP

Roads and Parking

Overview

Del Monte Avenue is a main entry point into the City and carries vehicles to the City's commercial, business, and tourism centers. Del Monte Avenue connects with the Lighthouse Tunnel to provide access to New Monterey, Lighthouse Avenue, Cannery Row, and Pacific Grove. The City's street pavement network consists of 191 centerline miles equaling a total pavement area of approximately 35.8 million square feet.

Lighthouse Curve is presently divided with two travel lanes southbound and three travel lanes northbound. With average daily traffic of over 53,000 vehicles per day on peak days, Lighthouse Curve is the City's most heavily traveled street and experiences a service level of D.

In support of the visitor amenities and attractions throughout the waterfront area, and as an interim use of acquired parcels, there are14,957 parking spaces. The parking lots are, for the most part, physically and functionally independent of one another.

Waterfront parking is managed by the City's Parking Division. Most parking spaces require a fee.

To quantify the impact of coastal hazards and climate change on roads and parking , the following measures of impacts have been identified:

- Number of traffic interruptions from hazards;
- Length of roads;
- Number of parking lots; and
- Number of parking spaces.

Existing Conditions

Historical

Historically, large storms have flooded Del Monte Ave causing disruption to bus routes and bike trails.

Present

Existing Hazards for this sector are largely concentrated along Del Monte Ave and along El Estero.

Length of Roads

- 590 feet of roads from coastal flooding.
- 494 feet from tidal inundation flooding.

Traffic Interruptions

- 11 from existing coastal flooding and tidal inundation

Parking lots (spaces)

- 1 parking lot exposed to coastal erosion (27 spaces)
- 4 parking lots exposed to coastal flooding (9 spaces)

FEMA Creek flooding 100 yr. - 500 yr.

- 15,107 – 17,691 feet of roads (2.9 – 3.4 miles).
- 65 and 96 interruptions from FEMA flooding.
- 16 - 27 parking lots.
- 720 – 2,092 parking spaces.

2030 Vulnerabilities (8.8 inches of sea level rise)

Vulnerabilities to coastal flooding expand along Del Monte Avenue near Lake El Estero.

Length of Roads

- 4,408 additional feet of roads from coastal flooding.
- 45 additional feet from tidal inundation flooding.

Traffic Interruptions

- 31 from existing coastal flooding and tidal inundation.

Parking lots (spaces)

- 4 additional parking lots exposed to coastal erosion (5 spaces).
- 10 parking lots exposed to coastal flooding (152 spaces).

2060 Vulnerabilities (28.3 inches of sea level rise)

Vulnerabilities to coastal flooding expand into lower Downtown and along Del Monte Avenue near El Estero.

Length of Roads

- 10,711 additional feet of roads from coastal flooding (2.1 miles).
- 1.205 additional feet from tidal inundation flooding.
- 79 feet of roads eroded.

Traffic Interruptions

- 70 from existing coastal flooding and tidal inundation.

Parking lots (spaces)

- 4 additional parking lots exposed to coastal erosion (23 spaces).
- 21 parking lots exposed to coastal flooding (1137 spaces).

2100 Vulnerabilities (62.6 inches of sea level rise)

Vulnerabilities expand into lower Downtown along Del Monte Avenue and El Estero, with a bit in Cannery Row.

Length of Roads

- 25,567 total feet of roads from coastal flooding (4.8 miles).
- 11,220 total feet from tidal inundation flooding (2.1 miles).
- 792 total feet of roads eroded.

Traffic Interruptions

- 241 interruptions from existing coastal flooding and tidal inundation.

Parking lots (spaces)

- 7 total parking lots exposed to coastal erosion (195 spaces).
- 45 total parking lots exposed to coastal flooding (3,337 spaces).

Additional Information

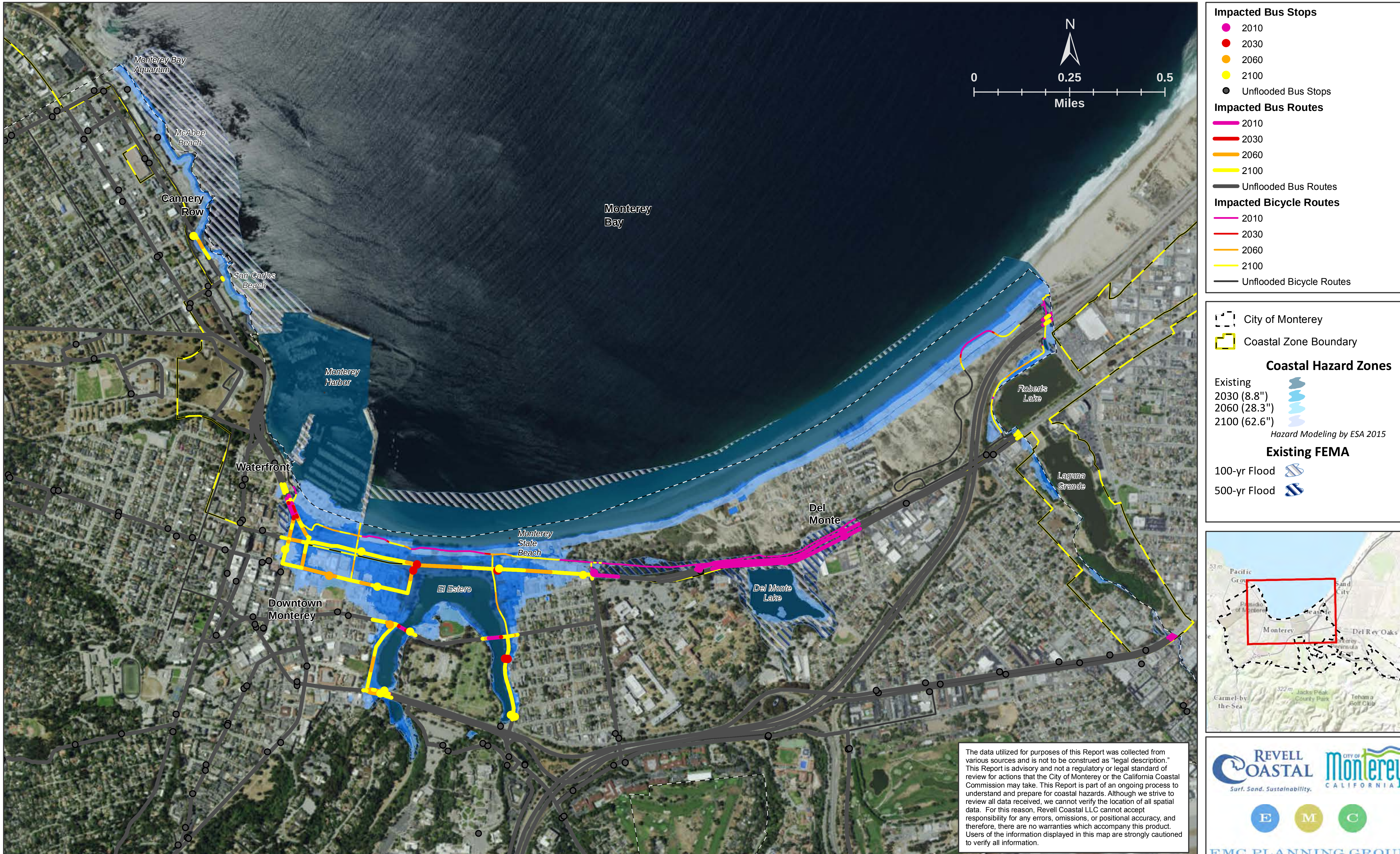
Findings

- By the year 2100, coastal flooding will temporarily impact 2,632 parking spaces.
- Existing hazards to roads are focused around Lake El Estero and gradually spread toward lower Downtown.
- Parking lots servicing San Carlos Beach and Wharf #2 face the highest existing threat with a threshold between 2030 and 2060 when vulnerabilities to parking and roads increasing substantively.

Recommendations

- Develop a solution for Del Monte Ave and the Waterfront, which may include elevating the road, realigning segments or other strategies.

Public Transportation - Buses, Bikes, and Pedestrians



Public Transportation

Overview

Monterey/Salinas Transit (MST) currently provides bus service to the City. The MST operates a shuttle linking Downtown and Cannery Row. The shuttle encourages motorists to park in the downtown parking garages and shuttle to Cannery Row.

In 1983, the City purchased the portion of the Southern Pacific rights-of-way (ROW) between the Seaside City Limits and Municipal Wharf #1 with an agreement to construct "an exclusive mass transit guideway project." The Monterey (?)Recreation Trail has been constructed on a portion of the ROW.

Bicycle Circulation - The Recreation Trail provides bicycle access along the coast connecting Seaside with Pacific Grove.

Pedestrian Circulation - The Recreation Trail also provides pedestrian access along the ocean front with other pedestrian pathways along Reeside Avenue to the Coast Guard Pier along San Carlos Beach and between Municipal Wharf # 1 and 2.

Measures of Impact

Present public transportation in the City includes about 1,208 miles of bus routes, 345 bus stops, and 22.2 miles of bike trails. Note that bus routes include travel in both directions along each route and differ from road length. Impacts from coastal hazards and climate change on public transportation, are quantified using the following measures of impacts:

- Number of bus stops
- Length of bus routes
- Length of bike and pedestrian trails

Existing Conditions

Historical

Historically, large storms have flooded Del Monte Ave causing disruption to bus routes and bike trails.

Present

Existing hazards exist along the Recreational Trail fronting Del Monte Ave and bus routes along Del Monte Lake, El Estero and lower Downtown.

Bus

- No bus stops exposed to coastal hazards
- 6,523 feet from coastal flooding

Bike trails

- 2,546 feet of bike trails subject to coastal flooding

FEMA Creek flooding 100 year - 500 year events

- 8-13 bus stops
- 38,855 – 87,478 feet of bus routes (7.3-16.6 miles)
- 6,205 -10,800 feet of bike routes (1.2 – 2.1 miles)

2030 Vulnerabilities (8.8 inches of sea level rise)

Vulnerabilities to coastal flooding expand along Del Monte Avenue near El Estero.

Bus

- 5 bus stops exposed to coastal flooding
- 21,377 additional feet from coastal flooding (4.0 miles)

Bike trails

- 2,809 additional feet of bike trails

2060 Vulnerabilities (28.3 inches of sea level rise)

Vulnerabilities to coastal flooding expand into lower Downtown and along Del Monte Avenue near El Estero.

Bus

- 11 additional bus stops exposed to coastal flooding
- 32,337 additional feet from coastal flooding (6.1 miles)

Bike trails

- 4,251 additional feet of bike trails exposed to coastal flooding

2100 Vulnerabilities (62.6 inches of sea level rise)

Vulnerabilities expand into lower Downtown along Del Monte Avenue and El Estero, with a bit in Cannery Row.

Bus

- 17 total bus stops exposed to coastal flooding; 1 bus stop exposed to coastal erosion in Cannery Row
- 91,436 total feet from coastal flooding (17.3 miles); 431 total feet from coastal erosion
- 44,464 total feet from tidal inundation (8.4 miles)

Bike trails

- 13,611 total feet from coastal flooding (2.6 miles); 2,506 total feet from coastal erosion along the Recreational Trail (0.6 miles)
- 5,407 total feet of bike trails exposed to tidal inundation (1.1 miles)

Additional Information

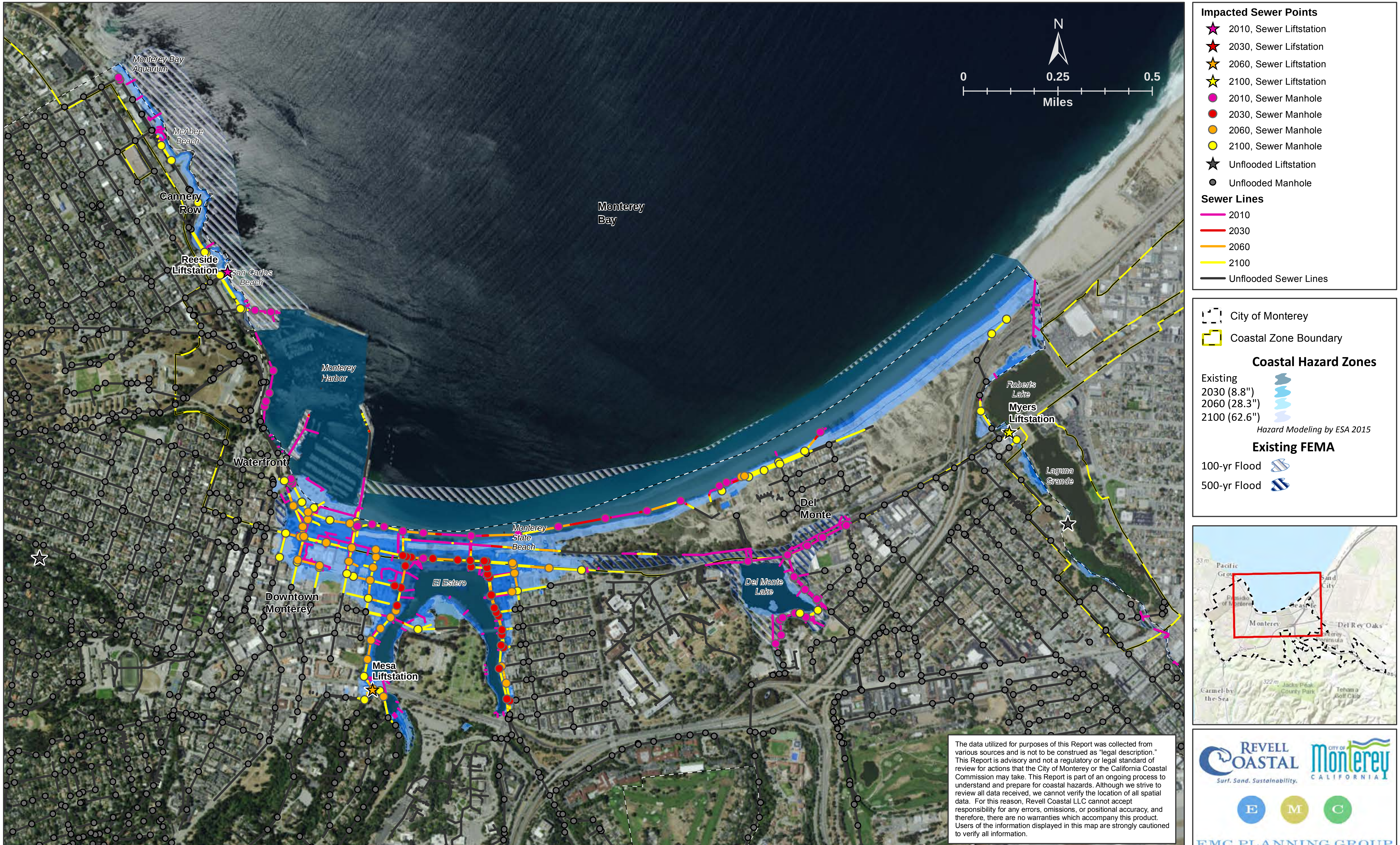
Findings

- Coastal flooding poses the largest vulnerability to public transportation with the Recreational Trail and Del Monte Avenue bus routes being the most vulnerable.
- Only one bus stop in the Cannery Row area is susceptible to coastal erosion with ~5 feet of sea level rise.
- Vulnerabilities to all public transportation metrics show a threshold between ~1 and 2 feet of sea level rise during which coastal flooding and erosion impacts escalate rapidly.

Recommendations

- Develop a solution for Del Monte Avenue..
- Develop alternative bus routes to avoid coastal hazards particularly those related to tidal inundation
- Identify alternate alignments for the Recreational Trail either by phasing inland retreat or other strategies.
- Collaborate with land owners, private and public entities to Realign existing routes.
- Incorporate vulnerability results into regional transportation planning.

Wastewater



Monterey Bay Aquarium
McAbee Beach
Cannery Row
Reeside Liftstation
San Carlos Beach
Monterey Bay
Monterey Harbor
Waterfront
Monterey State Beach
Del Monte
Roberts Lake
Myers Liftstation
Laguna Grande
Del Monte Lake
El Estero
Downtown Monterey
Mesa Liftstation
N
0
0.25
0.5
Miles
Impacted Sewer Points
2010, Sewer Liftstation
2030, Sewer Liftstation
2060, Sewer Liftstation
2100, Sewer Liftstation
2010, Sewer Manhole
2030, Sewer Manhole
2060, Sewer Manhole
2100, Sewer Manhole
Unflooded Liftstation
Unflooded Manhole
Sewer Lines
2010
2030
2060
2100
Unflooded Sewer Lines
City of Monterey
Coastal Zone Boundary
Coastal Hazard Zones
Existing
2030 (8.8")
2060 (28.3")
2100 (62.6")
Hazard Modeling by ESA 2015
Existing FEMA
100-yr Flood
500-yr Flood
Pacific Grove
Sand City
Seaside
Monterey
Del Rey Oaks
Carmel-by-the-Sea
The data utilized for purposes of this Report was collected from various sources and is not to be construed as “legal description.” This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.
REVELL COASTAL
Surf. Sand. Sustainability.
City of Monterey California
EMC PLANNING GROUP

Overview

Monterey's sewage is conveyed through interceptor pipelines to the Monterey Regional Water Pollution Control Agency (MRWPCA) sewer treatment plant in Marina for treatment and disposal. The City maintains the wastewater system within its jurisdiction. The sewer main runs under Del Monte Ave. The interceptor sewer line that connects Pacific Grove and Carmel to the treatment plant runs along the back of Del Monte Beach.

The MRWPCA is a joint powers authority formed in 1972 to consolidate wastewater management. Before the establishment of the MRWPCA, each community in the Monterey Bay area operated their own sewage treatment plan and discharged directly into the Monterey Bay with relatively short outfall pipes.

Following the Clean Water Act, and subsequent funding by 1983, several projects were completed to connect communities to the regional plant. Previous treatment plants were converted to pumping stations including the Reeside Pump Station and the Monterey Pump Station connected to one of 3 interceptor pipelines.

The Regional Treatment Plant represents an investment of approximately $150 million: $48 million for the connecting interceptors and pump stations; $28 million for the two mile ocean outfall; and $74 million for the Regional Treatment Plant.

Wastewater treated at the plant is largely used for irrigation of farmlands and groundwater injection to slow the rate of saltwater intrusion. Remaining wastewater is discharged via ocean outfall into Monterey Bay.

Monterey's existing sewer collection system is an aged one, and requires on-going maintenance and rehabilitation. The existing capacity of the system is adequate to convey the sewage generated, but the infrastructure needs repair. With this escalating maintenance costs in its current condition, it presents an opportunity to relocate and perhaps realign the system with future rail line corridors or road elevation.

Operations and maintenance of the wastewater collection system in the City includes approximately 117 miles of sewer lines and 7 pump stations. To quantify the impact of coastal hazards and climate change on wastewater infrastructure, the following measures of impacts have been identified:

- Number of pump stations;
- Length of pipe (feet); and
- Number of manholes.

Failure in the system means sewage could spill into the City and/or the Monterey Bay. Repairs could be passed onto rate payers within the City.

Existing Conditions

Historical

MRWPCA has no reported sewage spills in the City of Monterey.

Reeside Pump Station in Monterey is a part of the interceptor conveyance system.

Present

Number of Pump Stations

- 1 pump station at risk to Coastal Erosion (Reeside Station)
- 1 pump station (Mesa Lift Station) impacted by 500-yr FEMA flood hazard

Length of Pipe (feet)

- 4,946 feet of pipe at risk to Coastal Erosion, largely along Del Monte Beach under the beach
- 2,785 feet of pipe at risk to Coastal Flooding
- 1,375 feet of pipe at risk to Tidal Inundation
- 19,620 – 37,203 feet (3.7 – 7 miles) at risk to FEMA hazards

Number of Manholes

- 14 manholes at risk to Coastal Erosion
- 3 manholes at risk to Coastal Flooding
- 6 manholes at risk to Tidal Inundation
- 72-121 manholes at risk to FEMA flood hazards

2030 Vulnerabilities (8.8 inches of sea level rise)

Number of Pump Stations

- No additional pump stations at risk from coastal hazards in 2030.

Length of Pipe (feet)

- 731 additional feet of pipe at risk to Coastal Erosion
- 6568 additional feet of pipe at risk to Coastal Flooding
- 695 additional feet of pipe at risk to Tidal Inundation

Number of Manholes

- 2 additional manholes at risk to Coastal Erosion
- 28 additional manholes at risk to Coastal Flooding
- 1 additional manholes at risk to Tidal Inundation

2060 Vulnerabilities (28.3 inches of sea level rise)

Number of Pump Stations

- Mesa Pump Station pump at risk at risk to Coastal Flooding

Length of Pipe (feet)

- 1812 additional feet of pipe at risk to Coastal Erosion
- 10,887 additional feet of pipe (~2miles) along Del Monte Ave at risk to Coastal Flooding.
- 3,252 additional feet of pipe at risk to Tidal Inundation

Number of Manholes

- 1 additional manholes at risk to Coastal Erosion
- 36 additional manholes at risk to Coastal Flooding
- 10 additional manholes at risk to Tidal Inundation

2100 Vulnerabilities (62.6 inches of sea level rise)

Number of Pump Stations

- 1 total pump station at risk to Coastal Erosion (Reeside).
- 2 total pump stations at risk (Mesa and Myers Lift Station) at risk to Coastal Flooding.

Length of Pipe (feet)

- 13,620 total feet (~2.6 miles) at risk to Coastal Erosion
- 29,932 feet of pipe (~5.7 miles) at risk to Coastal Flooding
- 17,954 total feet (3.2 miles) at risk to Tidal Inundation

Number of Manholes

- 31 total manholes at risk to Coastal Erosion
- 93 total manholes at risk to Coastal Flooding
- 62 total manholes at risk to Tidal Inundation

Additional Information

Findings

- Nearly a mile of wastewater interceptor pipe is exposed to existing erosion hazards, this vulnerability increases with 5 feet of sea level rise to 2.6 miles. Coastal erosion impacts escalate between 2060 – 2100.
- Threshold 2010 to 2030 for manholes which when exposed to coastal flooding may Increase water volume into the aging wastewater system and cause the system to overload and spill into the City or Monterey Bay.
- By 2100, 62 manholes will be inundated by monthly tides.
- First pump station likely to be affected with ~2 feet of SLR.

Recommendations

- Encourage regional dialog about the future location of the Interceptor and sewer network.
- Add policy language to require relocation or avoidance of wastewater hazards to the extent possible.
- Conduct advanced maintenance to keep lines clear.
- Consider phased relocation of the sewer main
- Recommend flood proofing the pump stations.
- Relocate two pump stations in 2060 and 2100 hazard zones
- Retrofit manholes to reduce flood waters into sewer system.

Water Supply

REVELL COASTAL
Surf. Sand. Sustainability.
City of Monterey California
EMC PLANNING GROUP

Water Supply

Overview

Water is supplied to most of the Monterey Peninsula by the California American Water Company (Cal-Am) through wells in Carmel Valley and a well on the Seaside Aquifer. With the exception of Ryan Ranch and Fort Ord annexation area, the City is within the Monterey Peninsula Water Management District (MPWMD). Monterey has reached the limits of its water allocation and has very little water available to meet housing, economic, and public facility goals. The MPWMD has adopted rules that allow transfer of water between uses and adjacent sites under the same ownership. Such water credits may allow future development or use intensification prior to the creation of new water sources to the City.

State Water Resources Control Board Order No. 95-10 requires Cal-Am to reduce the water it pumps from the Carmel River by 20 percent now, and up to 75 percent in the future. New water development must first offset Cal-Am's unlawful diversions from Carmel River, before any water produced by Cal-Am can be used for new construction or use expansion. New sources of water are being explored.

Water recycling is actively done by Monterey Regional Water Pollution Control Agency (MRWPCA), which services the City, to reduce the saltwater intrusion into the aquifers and provide reclaimed water for the region for irrigation.

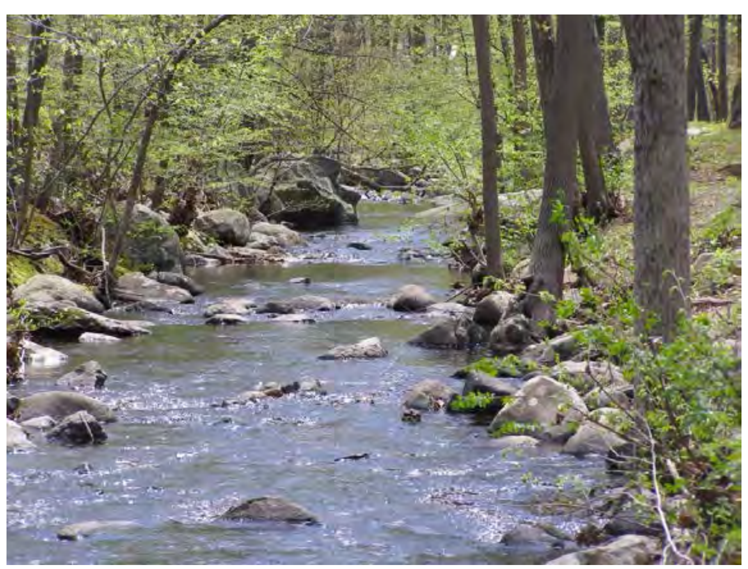
Present operations of the potable water supply system in the City include about 505 miles of supply lines and 1 lift station, 1,428 hydrants, 7 wells, and 1,506 control valves. To quantify the impact of coastal hazards and climate change on water supply infrastructure, the following measures of impacts have been identified:

- Number of lift stations;
- Length of pipe (feet);
- Number of hydrants;
- Number of control valves; and
- Number of wells.

Failure in the system could be passed onto ratepayers within the City.

Existing Conditions

Historical



Present

Presently, no lift stations, wells or valves are at risk from any coastal flooding in the City. The following vulnerabilities have been identified mainly along Del Monte Lake and Beach:

Length of pipe:

- 9,811 feet of pipe exposed to coastal erosion (1.9 miles)
- 872 feet exposed to coastal flooding

Number of hydrants:

- 1 hydrant exposed to coastal erosion and coastal flooding

FEMA Creek flooding 100 yr. - 500 yr.:

- 21,929 – 22,790 feet of pipe (4.1 – 4.3 miles)
- 66 - 130 control valves
- 18 - 28 hydrants

2030 Vulnerabilities (8.8 inches of sea level rise)

Vulnerabilities are located along Del Monte Avenue and El Estero including one lift station at risk from coastal flooding.

Length of pipe (feet);

- 78 additional feet exposed to coastal erosion (1.9 miles)
- 6,511 feet exposed to coastal flooding (1.2 miles)

Number of hydrants;

- 8 additional hydrants exposed to coastal flooding

Number of control valves

- 31 control valves exposed to coastal flooding

2060 Vulnerabilities (28.3 inches of sea level rise)

Vulnerabilities expand into the lower downtown portion of the City and along Del Monte Avenue. The same lift station at risk from flooding in 2030 becomes exposed to coastal erosion by 2060.

Length of pipe (feet);

- 331 additional feet of pipe exposed to coastal erosion (1.9 miles) along Del Monte Beach
- 13,660 feet exposed to coastal flooding (2.6 miles)

Number of hydrants;

- 18 hydrants exposed to coastal flooding

Number of control valves

- 91 additional control valves exposed to coastal flooding
- 1 control valve exposed to coastal erosion

2100 Vulnerabilities (62.6 inches of sea level rise)

Vulnerabilities continue to expand into the lower downtown portion of the City, along Del Monte Avenue, and near Roberts Lake. No water supply groundwater wells affected by 2100.

Length of pipe (feet);

- 13,408 feet of pipe exposed to coastal erosion (2.5 miles)
- 37,854 feet exposed to coastal flooding (7.2 miles)

Number of hydrants;

- 7 total hydrants exposed to coastal erosion
- 43 total hydrants exposed to coastal flooding

Number of control valves

- 195 total control valves exposed to coastal flooding
- 3 total control valves exposed to coastal erosion

Additional Information

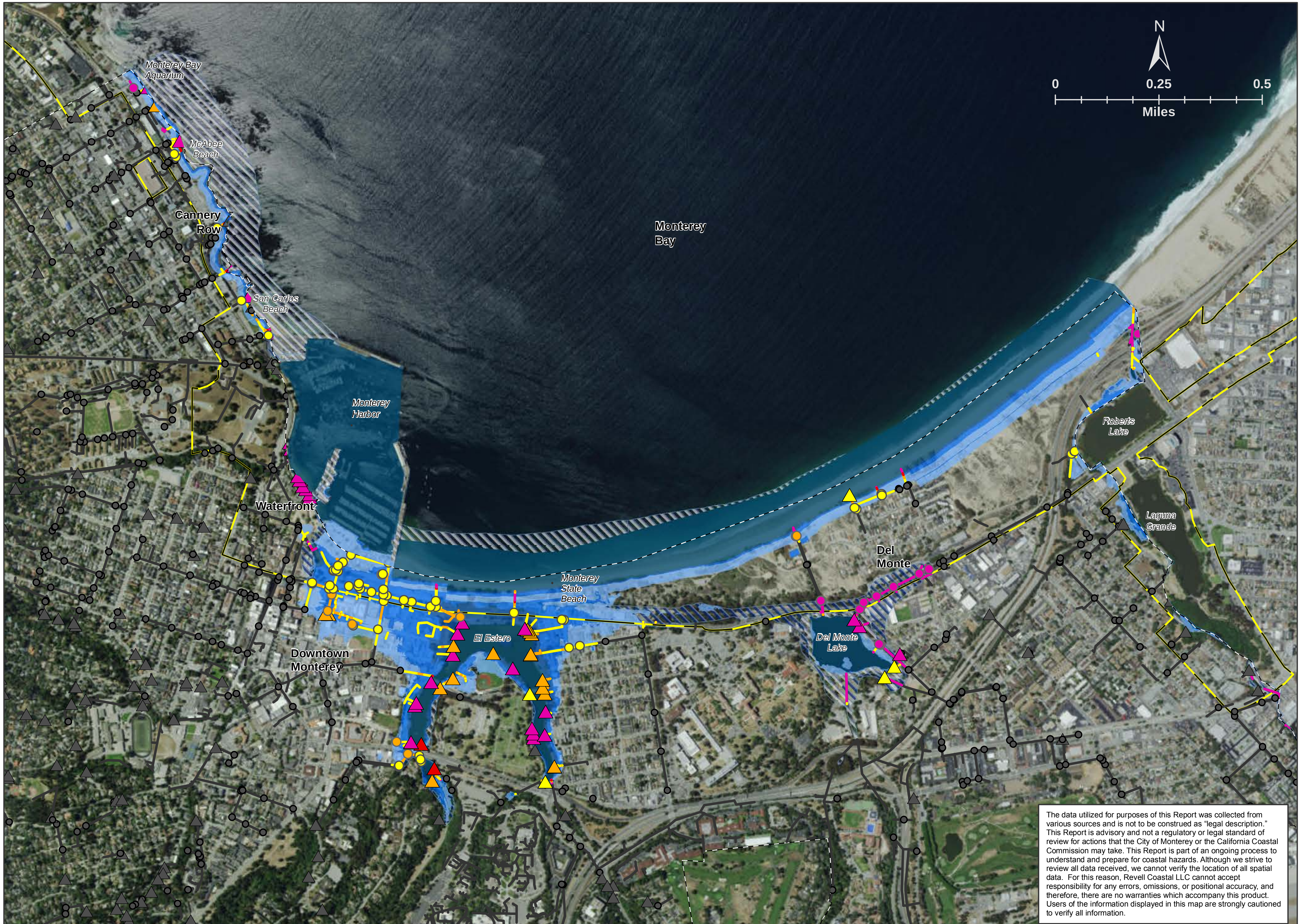
Findings

- No wells are projected to be vulnerable with ~5 feet of SLR
- The one lift station in the City is vulnerable to coastal. flooding by 2030 with less than 1 foot of SLR and by coastal erosion by 2060 with ~2 feet of sea level rise.
- Coastal erosion increases vulnerability to the water supply distribution and control system between 2060 and 2100.
- Threshold 2030 to 2060 for valves vulnerable to coastal flooding which will reduce the ability to manage the water supply system during storm events
- Threshold between 2060 and 2100 for hydrants vulnerable to coastal flooding and erosion may cause breaks in the system (erosion) and reduce the ability to manage the distribution (valves).

Recommendations

- Add policy language to require relocation or avoidance of water supply hazards to the extent possible.
- Recommend flood proofing the lift station by 2030.
- Recommend relocation of lift station away from coastal erosion hazard zones before 2 feet of sea level rise.
- Participate in regional water supply discussions to include topics of climate change.
- Restrict development of new wells in vulnerable areas.
- Ensure adequate long-term water supplies for the lifetime and intended use of any new development.

Stormwater



The data utilized for purposes of this Report was collected from various sources and is not to be construed as "legal description." This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.

Stormwater Points

- 2010 Stormwater Manhole
- 2030, Stormwater Manhole
- 2060, Stormwater Manhole
- 2100, Stormwater Manhole
- 2010, Stormwater Outlet
- 2030, Stormwater Outlet
- 2060, Stormwater Outlet
- 2100, Stormwater Outlet
- Unflooded Stormwater Manhole
- Unflooded Stormwater Outlet

Stormwater Lines

- 2010
- 2030
- 2060
- 2100
- Unflooded Stormwater Line

City of Monterey

Coastal Zone Boundary

Coastal Hazard Zones

Existing

2030 (8.8")

2060 (28.3")

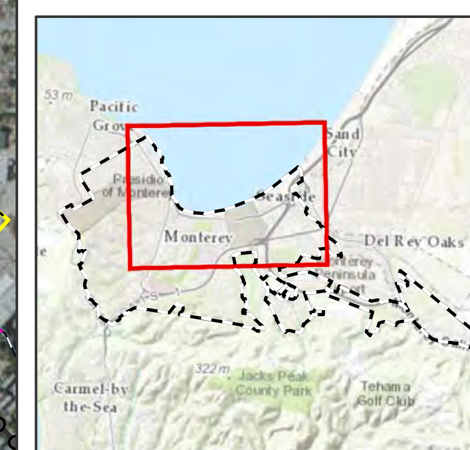
2100 (62.6")

Hazard Modeling by ESA 2015

Existing FEMA

100-yr Flood

500-yr Flood



REVELL COASTAL
Surf. Sand. Sustainability.

CITY OF Monterey CALIFORNIA

EMC PLANNING GROUP

Stormwater

Overview

The City of Monterey maintains its storm drainage infrastructure, including drainage channels, storm drains, pipelines, culverts, pump stations, and outfalls that discharge into the Monterey Bay. Monterey's storm water collection system is not tied into the sanitary sewer collection system Outfalls tend to flow either to the Monterey Bay, El Estero, Laguna Grande, or the Del Monte Lake.

Monterey's discharge of storm water to the Bay is regulated and permitted through a regional National Pollutant Discharge Elimination System (NPDES) permit from the Central Coast Regional Water Quality Control Board. In 2001, nine local agencies including the City formed the Monterey Regional Storm Water Management Program.

Monterey's coastal zone is located at the downstream end, or terminus, of various drainage areas where storm water flows converge and discharge to the Bay. Historically storm water infrastructure has experienced localized flooding of streets and sidewalks, due to joint occurrence of storm water with high tides and storm surges, conditions exacerbated by El Niño events.

The high tide and stormwater events result in the occasional flooding around Del Monte Ave, El Estero, and the Naval Postgraduate School.

Monterey's existing storm water collection system is an aged one that is in need of repair. The City Public Works Dept. documented the existing conditions of the system and identified segments in need of rehabilitation. Operations to maintain the wastewater collection system including approximately 1,838 storm drains, 87 miles of storm water lines, 731 manholes and 328 outfalls. To quantify the impact of coastal hazards and climate change on storm water infrastructure, the following measures of impacts have been identified:

- Number of storm drains;
- Length of pipe (feet);
- Number of manholes;
- Number of outfalls; and
- Number of outfalls below future Mean High Tide.

Existing Conditions

Localized flooding is often caused by heavy precipitation occurring during high tides when the stormwater system is slow to drain. The more outfalls that are below Mean High Tide (MHT) the less efficient any stormwater conveyance system will operate as they drain primarily when it is low tide.

Number of Storm Drains

- 2 storm drains at risk of Tidal Inundation.
- 56-99 storm drains at risk to FEMA flood hazards.

Length of Pipe (feet)

- 212 feet of pipe at risk of Coastal Erosion.
- 918 feet of pipe at risk of Coastal Flooding.
- 250 feet of pipe at risk of Tidal Inundation.
- 9,399 – 14,818 feet of pipe (1.7 – 2.8 miles) at risk to FEMA flood hazards.

Number of Manholes

- 14 manholes at risk of Coastal Erosion.
- 5 manholes at risk of Coastal Flooding.
- 11 - 49 manholes at risk to FEMA flood hazards

Number of Outfalls

- 1 outfalls at risk of Coastal Erosion
- 26 outfalls at risk of Coastal Flooding
- 24 outfalls at risk of Tidal Inundation
- 44 - 58 outfalls at risk to FEMA flood hazards.

Number of Outfalls below Mean High Tide

- 27 total outfalls below 4.6 feet (NAVD88).

2030 Vulnerabilities (8.8 inches of sea level rise)

Number of Storm Drains

- 1 additional storm drain at risk of Coastal Erosion.
- 32 additional storm drains at risk of Coastal Flooding.

Length of Pipe (feet)

- 241 additional feet of pipe at risk of Coastal Erosion.
- 4,278 additional feet of pipe at risk of Coastal Flooding.
- 48 additional feet of pipe at risk of Tidal Inundation.

Number of Manholes

- 3 additional manholes at risk of Coastal Flooding.

Number of Outfalls

- 7 additional outfalls at risk of Coastal Flooding.
- 2 additional outfalls at risk of Tidal Inundation.

Number of Outfalls below Water Surface Elevation

- 27 total outfalls below 5.4 feet (NAVD88).

2060 Vulnerabilities (28.3 inches of sea level rise)

Number of Storm Drains

- 12 additional storm drains at risk of Coastal Erosion.
- 70 additional storm drains at risk of Coastal Flooding.
- 14 additional storm drains at risk of Tidal Inundation.

Length of Pipe (feet)

- 850 additional feet of pipe at risk of Coastal Erosion.
- 8,520 additional feet of pipe (1.6 miles) at risk of Coastal Flooding.
- 1,419 additional feet of pipe at risk of Tidal Inundation.

Number of Manholes

- 36 additional manholes at risk of Coastal Flooding.
- 1 additional manhole at risk of Tidal Inundation.

Number of Outfalls

- 1 additional outfall at risk of Coastal Erosion.
- 4 additional outfalls at risk of Coastal Flooding.
- 14 additional outfalls at risk of Tidal Inundation.

Number of Outfalls below Water Surface Elevation

- 30 total outfalls below 7.0 feet (NAVD88).

2100 Vulnerabilities (62.6 inches of sea level rise)

Number of Storm Drains

- 28 storm drains at risk of Coastal Erosion.
- 143 storm drains at risk of Coastal Flooding.
- 96 storm drains at risk of Tidal Inundation.

Length of Pipe (feet)

- 3,743 total feet of pipe (2.2 miles) at risk of Coastal Erosion.
- 20,297 total feet of pipe (3.8 miles) at risk of Coastal Flooding.
- 11,378 total feet of pipe (2 miles) at risk of Tidal Inundation.

Number of Manholes

- 8 manholes at risk of Coastal Erosion.
- 59 manholes at risk of Coastal Flooding.
- 29 manholes at risk of Tidal Inundation.

Number of Outfalls

- 2 total outfalls at risk of Coastal Erosion.
- 39 total outfalls at risk of Coastal Flooding.
- 43 total outfalls at risk of Tidal Inundation.

Number of Outfalls below Water Surface Elevation

- 62 total outfalls below 9.8 feet (NAVD88).

Additional Information

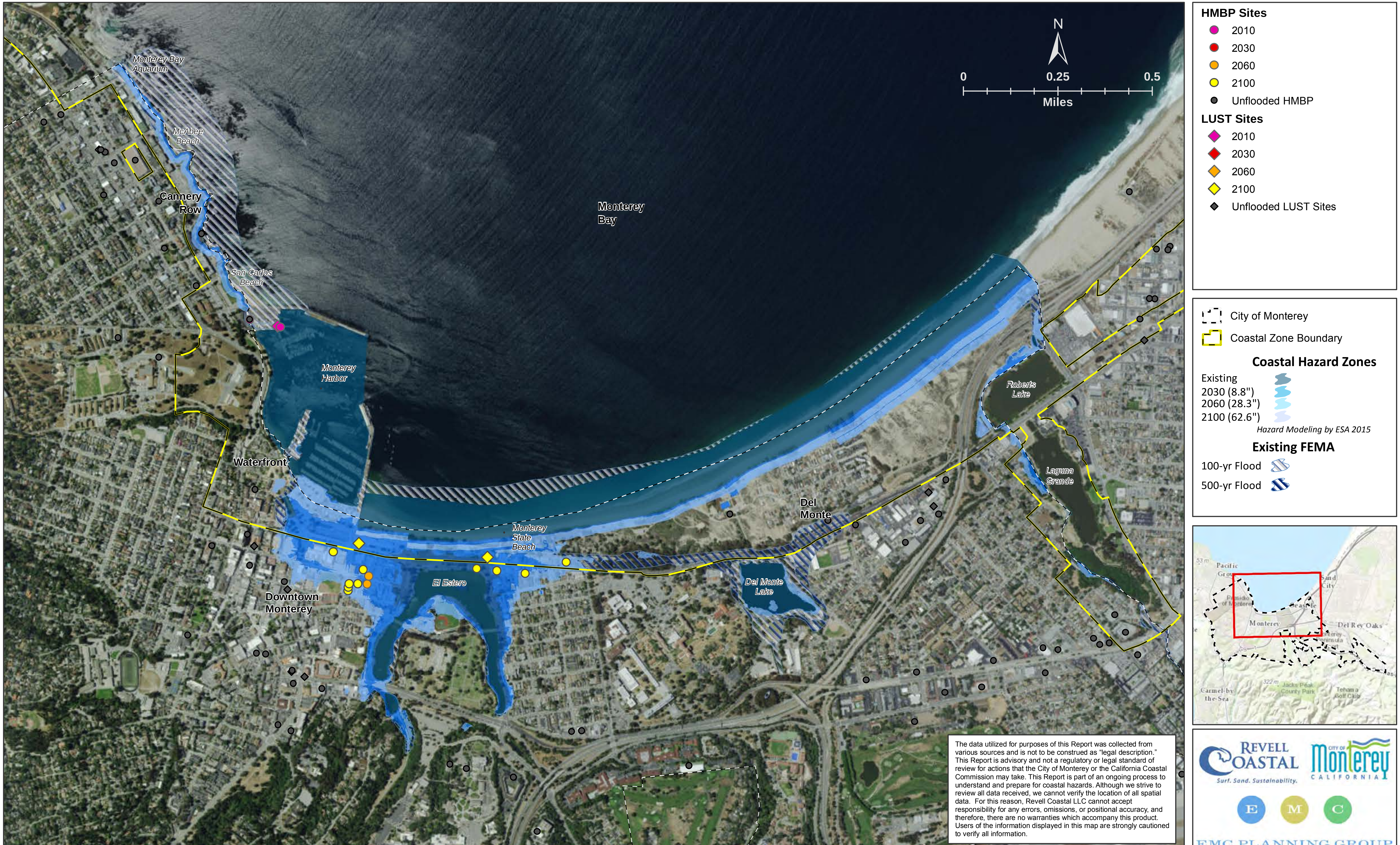
Findings

- The number of vulnerable stormwater outfalls more than doubles between existing and 2100 and may increase localized flooding.
- Threshold 2030 to 2060 for manholes and storm drains during which increasing exposure to coastal flooding may increase the volume of stormwater that needs to be conveyed.
- Coastal erosion impacts escalate between 2060 – 2100
- Flooding impacts to storm drains reaches threshold between ~1 and 2 feet.

Recommendations

- Add policy language to require relocation or avoidance of stormwater hazards to the greatest extent possible.
- Conduct advanced maintenance to keep lines clear.
- Recommend retrofit to manhole covers to flood proof them, which will prevent an additional source for entry into the stormwater system.
- Consider improving stormwater storage capacity with detention basins.
- Consider stormwater capture and treatment for groundwater injection and irrigation purposes.

Hazardous Materials



Hazardous Materials

Overview

There are two types of hazardous materials evaluated in this Report: 1) businesses that store hazardous materials and 2) leaky underground storage tanks (LUSTs). The type of chemical and the state (solid, liquid or gas) determines the relative risk of dispersal to the City. Facilities located near the City have the potential of causing damages within the City.

Businesses using hazardous materials are required to file a Hazardous Material Business Plan (HMBP) with the Monterey County Health Department specifically the Hazardous Materials Management Services. This department is responsible for inspecting facilities in the County (and City of Monterey) to verify proper storage, handling and disposal of hazardous materials and hazardous wastes.

In the event of a release of hazardous materials to the environment, the City would direct a response as the "first responder". The County Environmental Health Division Hazardous Materials Branch and the City of Seaside Hazardous Materials Team would likely be the first agencies to provide support to the City in the event that the City does not have the capacity or capability to fully address the hazard.

Measures of Impact

Hazardous chemicals are associated with dentist offices, medical supplies, laundry mats, auto repair shops, etc. In 2016, there were 142 HMBPs filed within the City.

LUSTs are often associated with gas stations, and contaminants can leak into the surrounding groundwater table and disperse or flow based on groundwater elevations. As of 2016, there are 119 LUSTs in various stages of remediation with 22 still in open status.

To quantify the impact of coastal hazards and climate change on hazardous materials, the following measures of impacts have been identified:

- Number of Hazardous Materials Business Plans (HMBP).
- Number of leaking underground storage tanks (LUST) with Open Cases that still require some environmental clean-up and monitoring.

Existing Conditions

Historical

Historically, the City had 119 LUSTs of which 97 sites have been completed and case closed (effectively cleaned up/remediated). The 22 remaining sites are scattered around the City, located along Del Monte Ave and lower Downtown.

Present

Number of HMBP Sites

- 1 HMBP site at risk to Tidal Inundation and Coastal Flooding
- 4-11 HMBP sites at risk to FEMA flood hazards

The majority of the existing HMBP sites are presently located near the Coast Guard Pier and Landfill Parcel. The one existing site exposed to coastal hazards is located in the Monterey Harbor at Monterey Bay Boatworks.

Number of LUST Sites

- 0 LUST at risk to Coastal Flooding and Tidal Inundation
- 1-2 LUSTs at risk to FEMA flood hazards.

2030 Vulnerabilities (8.8 inches of sea level rise)

Number of HMBP Sites

- 1 additional HMBP site at risk to Coastal Flooding, located at Lake El Estero and listed as owned by the City of Monterey.

Number of LUST Sites

- 0 additional LUST site at risk in 2030.

2060 Vulnerabilities (28.3 inches of sea level rise)

Vulnerabilities expand into the lower downtown portion of the City and along Del Monte Avenue.

Number of HMBP Sites

- 3 additional HMBP sites at risk to Coastal Flooding

Number of LUST Sites

- 1 additional LUST at risk to Coastal Flooding, located in the Del Monte Ave area.

2100 Vulnerabilities (62.6 inches of sea level rise)

Vulnerabilities expand into the lower downtown portion of the City and along Del Monte Avenue and into lower Downtown.

Number of HMBP Sites

- 12 total HMBP sites at risk to Coastal Flooding
- 3 total HMBP sites at risk to Tidal Inundation

Number of LUST Sites

- 2 total LUST sites at risk to Coastal Flooding

Additional Information

Findings

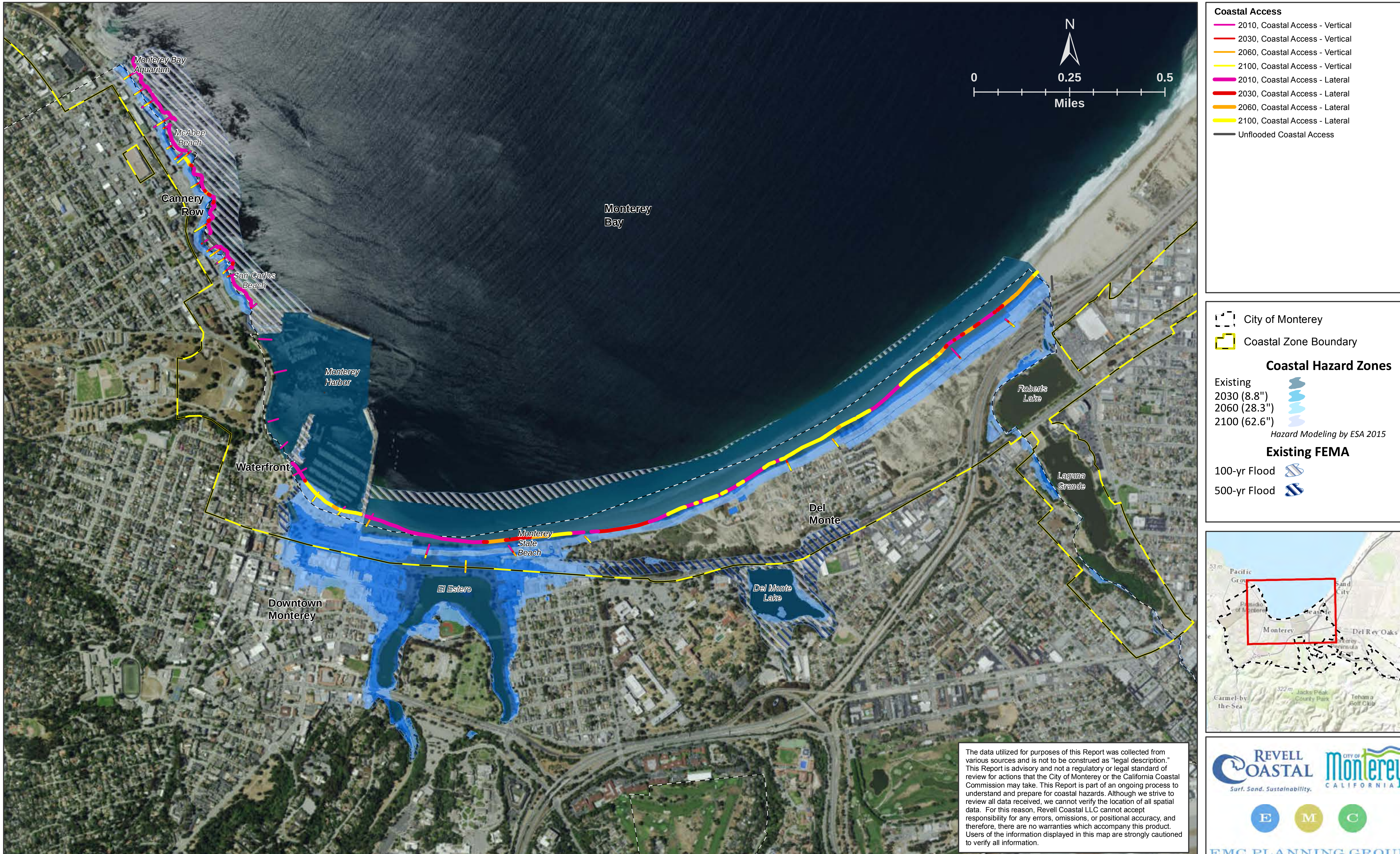
- Most existing HMBPs are located in the harbor and are associated with coastal dependent uses.
- Similar thresholds exist for both HMBPs and LUSTs, between 2 and 5 feet when the additional locations become vulnerable to coastal flooding along Del Monte Ave and Lower Downton.

Disclaimer: LUST and HMBP sites outside, but near the City were not included in this analysis. Coastal confluence flooding in the future is unavailable and should be considered in a future update. The type and quantity of hazardous materials, state of matter, dispersal mechanism and solubility in water was beyond the scale of this analysis.

Recommendations

- Establish more stringent policies for timing associated with cleanup. The timing would be based upon projected exposure to flooding.
- Establish policies that would not allow for sites that required certain hazardous materials within the coastal hazard zones.
- Locate funding for the active cleanup of HMBP sites affected by coastal hazards, mainly automotive service centers, gas stations and City of Monterey operations.
- Establish policies regarding storage for hazardous materials that would require additional elevation and containment. Finalize and complete open status LUST sites prior to long term flooding associated with coastal flooding, tidal inundation and elevated groundwater.

Beach Access and Trails



Beach Access and Trails

Overview

The Monterey Bay is the City's most significant natural resource.

Views of the Monterey Bay are also protected as a resource and provide public access to the shoreline and beaches. Key beach parks include Del Monte Beach, San Carlos Beach, and McAbee Beach.

Vertical access ways – total of 35 in the City

Lateral access ways– total of 9 in the City

Scenic access areas – total of 21,636 feet (4.1 miles)

In addition the recreational bike and pedestrian trail runs along the ocean front through the City connecting the City of Seaside with the City of Pacific Grove.

To quantify the impact of coastal hazards and climate change on beach access and parks, the following measures of impacts have been identified:

- Number of vertical beach access ways;
- Number of lateral beach access ways; and
- Length of trails (feet).

Existing Conditions

Historical

Trails are largely aligned along the former Southern Pacific Railroad alignment that has been partially purchased over the last 50 years through conservation easements.

Coastal erosion permanently interrupts the trail continuity and threatens vertical beach accessways (e.g. stairs) as portions of the trail are eroded. Coastal flooding temporarily interrupts the trail for a short time period. The time period is dependent on the elevation and duration of flood events.

Lateral beach access during high tides will be impaired until such time that the existing armoring and development is removed.

Present

Most beach accesses located along Cannery Row and the Waterfront area are presently vulnerable to coastal hazards.

Beach Access Vertical / Lateral

- 4 vertical / 2 lateral accesses exposed to erosion
- 4 vertical / 1 lateral access exposed to coastal flooding
- 7 vertical / 3 lateral accesses exposed to tidal inundation

Length of trails

- 9,639 feet exposed to coastal erosion (1.8 miles)
- 3,442 feet exposed to coastal flooding and inundation

FEMA Creek flooding 100 yr. - 500 yr.

- 29 – 43 vertical accesses / 15 – 17 lateral accesses
- 15,288 - 17,291 feet of trail (2.9 miles – 3.3 miles)

2030 Vulnerabilities (8.8 inches of sea level rise)

Beach Access Vertical / Lateral

- 20 additional vertical accesses / 3 lateral additional accesses exposed to coastal erosion
- 7 additional vertical accesses / 4 lateral additional accesses exposed to coastal flooding
- 1 additional vertical access / 3 lateral additional accesses exposed to tidal inundation

Length of trails

- 472 additional feet exposed to coastal erosion
- 966 additional feet exposed to coastal flooding and inundation
- 462 additional feet exposed to tidal inundation

2060 Vulnerabilities (28.3 inches of sea level rise)

Vulnerabilities expand into the lower downtown portion of the City and along Del Monte Avenue. Some of the connector trails from inland to the Recreational Trail become exposed to coastal flooding.

Beach Access Vertical / Lateral

- 21 additional vertical accesses / 2 lateral additional accesses exposed to coastal erosion
- 9 additional vertical accesses / 2 lateral additional accesses exposed to coastal flooding
- 4 additional vertical accesses / 3 lateral additional accesses exposed to tidal inundation

Length of trails

- 817 additional feet exposed to coastal erosion
- 966 additional feet exposed to coastal flooding and inundation
- 1,349 additional feet exposed to tidal inundation

2100 Vulnerabilities (62.6 inches of sea level rise)

Vulnerabilities continue to expand into the lower downtown portion of the City, along Del Monte Avenue, and near Roberts Lake. Inland portions of Cannery Row access points are further affected by erosion.

Beach Access Vertical / Lateral

- 25 total vertical accesses / 4 total lateral accesses exposed to coastal erosion from existing conditions
- 11 total vertical accesses / 2 total lateral accesses exposed to coastal flooding from existing conditions
- 9 total vertical accesses / 3 total lateral accesses exposed to tidal inundation from existing conditions

Length of trails

- 13,112 total feet exposed to coastal erosion (2.5 miles) from existing conditions
- 3,140 total feet exposed to coastal flooding (0.7 miles) from existing conditions
- 8,783 total feet exposed to tidal inundation (1.7 miles) from existing conditions

Additional Information

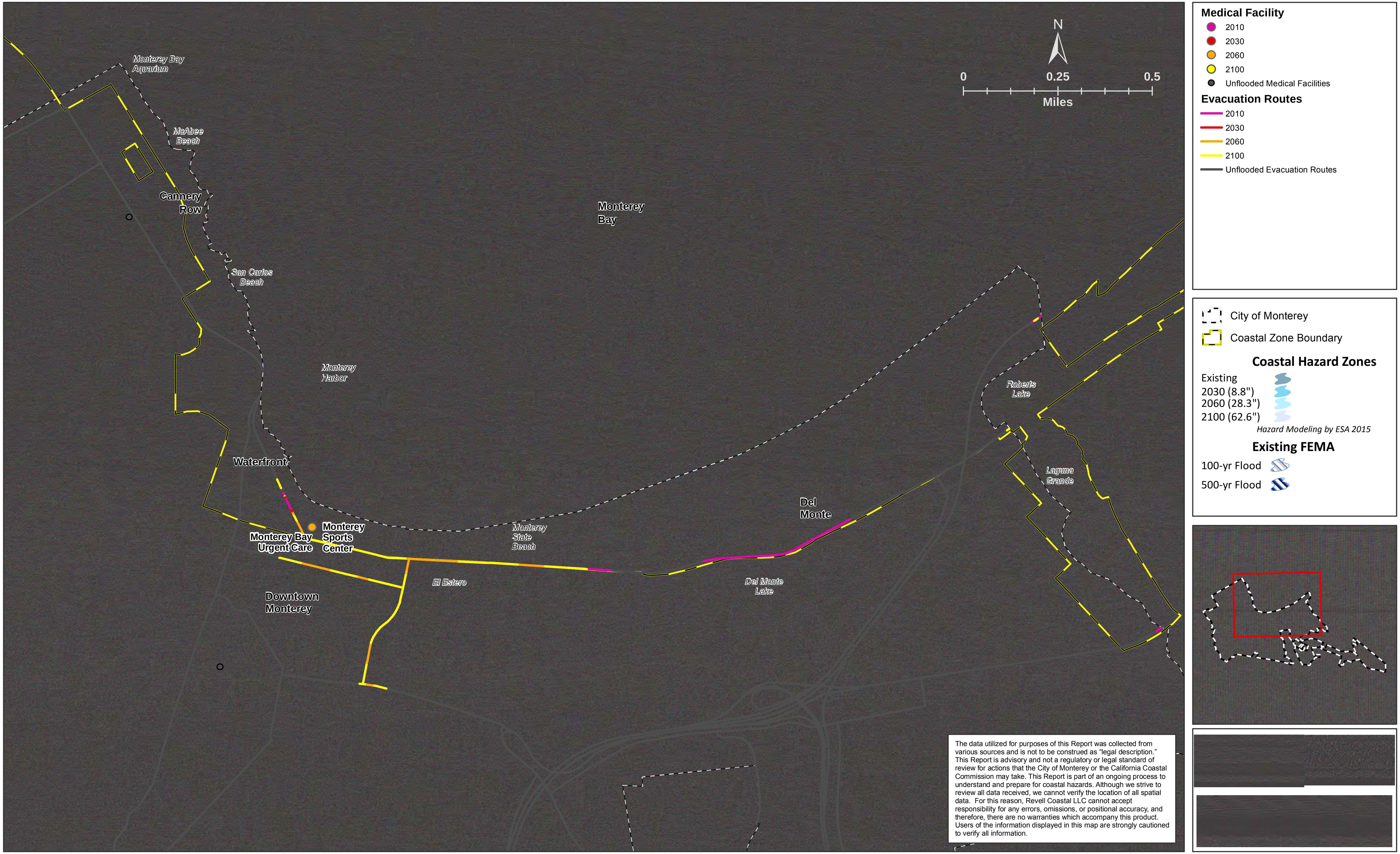
Findings

- The majority of the coastal Recreational Trail is vulnerable to existing coastal erosion, flooding and FEMA creek hazards
- 45 percent of the Recreational Trail is in the vulnerable to coastal erosion under the existing conditions.
- By 2030, the majority of vertical accesses are vulnerable to coastal erosion (60%)
- By 2060, nearly one third of the vertical access are vulnerable to coastal flooding (32%)
- By 2100 all vertical and lateral accesses are vulnerable to coastal erosion and coastal flooding

Recommendations

- Develop strategies to maintain, create, and improve vertical and lateral beach accesses.
- Develop Public Access policies that encourage establishment of new lateral access points that fluctuate with and accommodate higher levels of sea level rise and coastal hazards.
- Identify suitable retreat locations for coastal trails.

Emergency Services and Evacuation Routes



Emergency Services and Evacuation Routes

Overview

The City of Monterey Fire Department and Police Department coordinate emergency response within the City. The City operates its Emergency Operations Center (EOC) as the nucleus of emergency response coordination and actions. During an emergency, the EOC, including information, equipment, volunteers, and other resources manage all response activities. Plans for responses to emergency situations are formulated by fire and police officials and actions to implement those plans are communicated to emergency response teams that operate out of the EOC and throughout the City. The self-contained, 1,300-foot facility is located behind the Police Department.

The City's emergency response efforts are coordinated under the broader umbrella of the State of California Office of Emergency Services. The County of Monterey also has an emergency response office.

Evacuation Routes for the City of Monterey that lead to more inland areas and/or higher elevation including the following:

- Casa Verde Way south to Fremont St.
- Sloat Ave. south to Mark Thomas Dr.
- Abrego St. / Munras Ave. south to El Dorado St. / Del Monte Center
- Pacific St. south to El Dorado St. / Monterey High School
- Franklin St. west to Van Buren St.
- Any street in New Monterey that trends uphill

A total of 10 government facilities and 9 medical facilities are located throughout City limits, primarily in Downtown. In case of any major emergency, Incident Command would be established at Monterey Police Department, located at 351 Madison Street in Monterey. A total of 164,322 feet (31.1 miles) of evacuation routes are located in City limits. To quantify the impact of coastal hazards and climate change on emergency services and evacuation routes, the following measures of impacts have been identified:

- Number of Government facilities;
- Number of Health Care facilities; and
- Length of evacuation route (feet).

Existing Conditions

Historical

The City of Monterey faces more logistical challenges and potential problems associated with a tsunami warning and evacuation than any other city in Monterey County. This is due to both a large area that is very low-lying and a high concentration of businesses and people immediately adjacent to the coast. The City also faces the potential for inland inundation, where many homes may be affected. The areas of greatest concern are the city beaches, Del Monte Avenue west of Sloat Avenue, El Estero Park and adjacent neighborhoods, Monterey Harbor, Fisherman's Wharf, and Cannery Row. Portions of Downtown Monterey, although not as low-lying as other areas, have the potential to be inundated as well. There are also individual spots of concern, including the Monterey Beach Resort, Ocean Harbor House condominium complex, the U.S. Coast Guard Station, the Lighthouse Ave tunnel, the La Playa Condominium project, and the Monterey Bay Aquarium, among others.

Present

- **Health Care Facility** 1 Health Care facility impacted by FEMA flood hazards (Monterey Bay Urgent Care).

Length of Evacuation Routes (feet)

- 241 feet impacted by Coastal Flooding.
- 12,023 feet (2.3 miles) evacuation routes impacted by FEMA flood hazards near Del Monte Lake.

2030 Vulnerabilities (8.8 inches of sea level rise)

Health Care Facility

- 0 additional Health Care facilities impacted in 2030

Length of Evacuation Routes (feet)

2,126 additional feet (0.4 miles) of evacuation routes impacted by Coastal Flooding around the Lower Downtown area.

2060 Vulnerabilities (28.3 inches of sea level rise)

Health Care Facility

- 1 Health Care facility impacted by Coastal Flooding (Monterey Bay Urgent Care).

Length of Evacuation Routes (feet)

- 4,332 additional feet (0.8 miles) of evacuation routes impacted by Coastal Flooding primarily along El Estero.

2100 Vulnerabilities (62.6 inches of sea level rise)

Health Care Facility

- 1 total Health Care facility impacted by Coastal Flooding (Monterey Bay Urgent Care).

Length of Evacuation Routes (feet)

- 8,934 total feet (1.7 miles) of evacuation routes impacted by Coastal Flooding along Del Monte Ave and Lower Downtown.
- 5,253 total feet (1 mile) of evacuation routes impacted by Tidal Inundation.

Additional Information

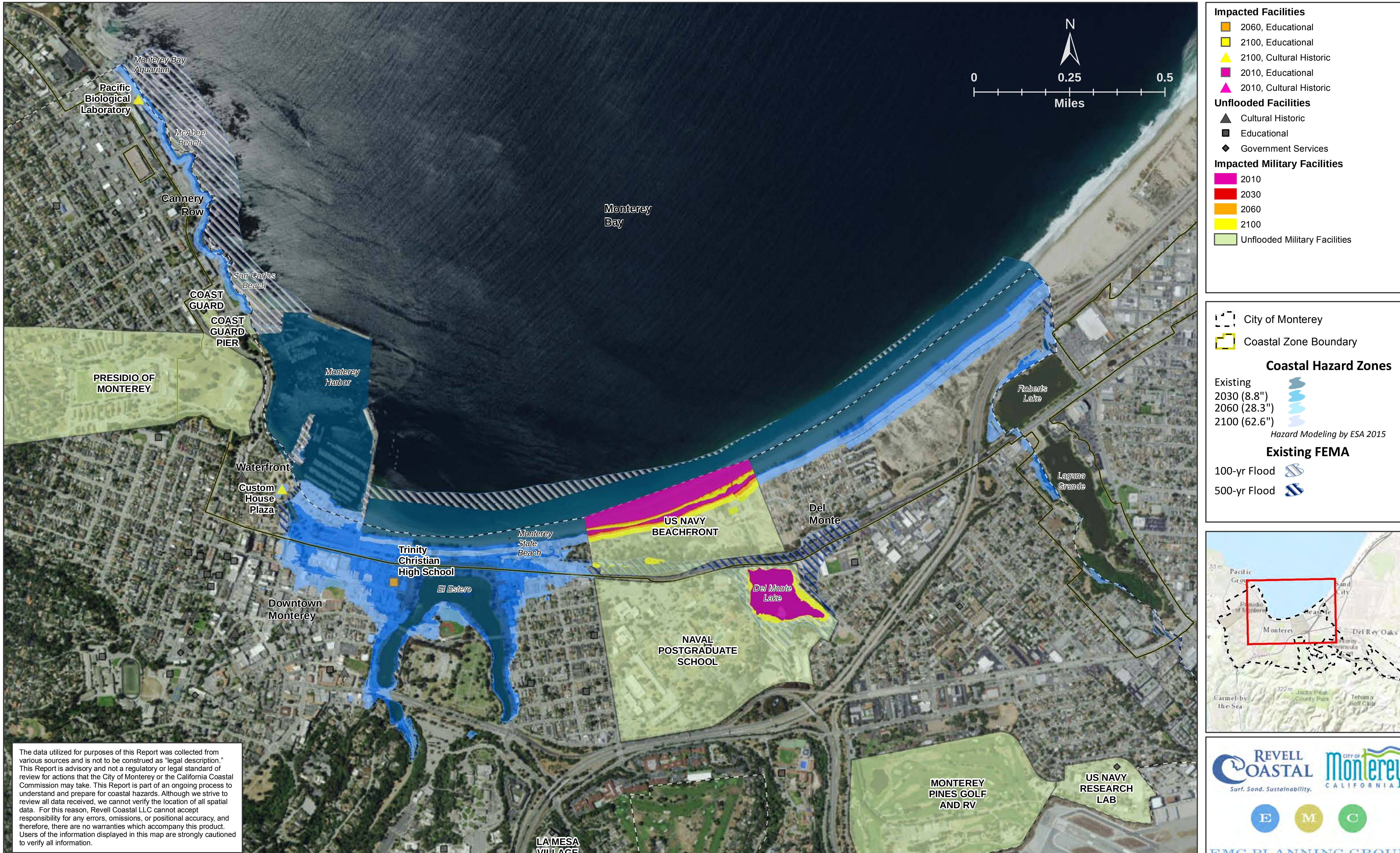
Findings

- There are no medical facilities at risk from climate induced coastal hazards with up 5 feet of sea level rise.
- There are no evacuation routes vulnerable to coastal erosion with up to 5 feet of sea level rise.
- Evacuation impacts occur primarily along the Del Monte Ave corridor.
- Monterey Sports Center is impacted by coastal flooding and tidal hazards, which is identified as potential evacuation center.

Recommendations

- Continue to monitor the location of existing facilities and associated evacuation routes within and adjacent coastal hazard zones.
- Any changes to roads used for evacuation (e.g. Del Monte) should consider emergency services to ensure roadways are wide enough as responders depend on accessibility to any affected areas.
- Consider relocating evacuation center.

Public and Military Facilities



The data utilized for purposes of this Report was collected from various sources and is not to be construed as "legal description." This Report is advisory and not a regulatory or legal standard of review for actions that the City of Monterey or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for coastal hazards. Although we strive to review all data received, we cannot verify the location of all spatial data. For this reason, Revell Coastal LLC cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in this map are strongly cautioned to verify all information.

Public and Military Facilities

Overview

Monterey was founded on June 3, 1770 and incorporated on May 30, 1850. Monterey hosted California's first Constitutional Convention in historic Colton Hall, where on October 13, 1849, the original state of California constitution was signed. In the 1930's and 40's, Monterey became the center of a thriving fishing industry and the sardine capital of the world. Today, a smaller commercial fishing fleet continues to operate from the City's harbor marina at Wharf #2. As a result of this history there are many cultural and historic resources that define the City of Monterey. The City has a Historic Preservation Program that consists of several components including, a Historic Preservation Element, Historic Master Plan, and citywide historic survey program.

Public facilities include schools, military facilities, cemetery, parking facilities, hospitals, museums, and historic buildings. The Defense Language Institute, Monterey Peninsula College, the Monterey Institute for International Studies and the Naval Post Graduate School are the most significant institutional uses. The three military institutions in the City of Monterey, the Defense Language Institute, the Naval Post Graduate School, and the Coast Guard Station comprise a significant percentage of the total acreage within the public/governmental facilities.

The Monterey Bay Unified School District (MPUSD) provides public school service to the City of Monterey. Public schools include the following:

- Bayview Academy (Charter);
- Monterey Vista
- La Mesa Elementary;
- Foothill Elementary;
- Colton School; and
- Monterey High School.

Private schools include the following:

- Santa Catalina School;
- Trinity Christian High School;
- San Carlos Elementary School.

A total of 11 Cultural Resources, 27 schools and 11 Military installations located throughout City limits. To quantify the impact of coastal hazards and climate change on infrastructure, the following measures of impacts have been identified:

- Number of Cultural Resources;
- Number of Schools; and
- Number of Military Installations.

Existing Conditions

Historical

Present

Cultural Resources

- No cultural resources are at risk within Existing Conditions.
- 1 Cultural Resource affected in 500-yr Flood Zone (Pacific Biological Laboratory).

Schools

- 1 school impacted in 100-yr flood hazard (Trinity Christian High School).

Military Installations

- 1 military installation impacted by Coastal Erosion (US Navy Beachfront).
- 2 military installations at risk to Tidal Inundation (US Coast Guard Pier, US Navy Beachfront).
- 3 military installations impacted in 100-yr flood hazards (US Coast Guard Pier, US Navy Beachfront and Naval Postgraduate School).

2030 Vulnerabilities (8.8 inches of sea level rise)

Cultural Resources

- No Cultural Resources are impacted by 2030.

Schools

- No schools are impacted by 2030.

Military Installations

- 2 military installations are impacted associated with Coastal Flooding (US Navy Beachfront and Naval Postgraduate School).

2060 Vulnerabilities (28.3 inches of sea level rise)

Cultural Resources

- No Cultural Resources are impacted in 2060.

Schools

- 1 school impacted by Coastal Flooding (Trinity Christian High School).

Military Installations

- No additional military installations impacted by 2060.

2100 Vulnerabilities (62.6 inches of sea level rise)

Cultural Resources

- 1 cultural resource is impacted by Coastal Erosion (Pacific Biological Laboratory).
- 1 cultural resource is impacted by Coastal Flooding (Custom House Plaza).

Schools

- 1 school is impacted by Coastal Flooding and Tidal Inundation (Trinity Christian High School).
- 1 school is impacted by (Trinity Christian High School).

Military Installations

- 2 total military installations are impacted by Coastal Erosion, Coastal Flooding, and Tidal Inundation (US Navy Beachfront and Naval Postgraduate School).

Additional Information

Findings

- Trinity Christian High School is the only school vulnerable to coastal hazards and sea level rise.
- Portions of the Naval Postgraduate School and associated beach front is vulnerable to the full suite of coastal hazards with 5 feet of sea level rise.
- The Pacific Biological Laboratory becomes impacted by coastal erosion with 5 feet of sea level rise

Recommendations

- By 2100, exposure to tidal inundation may warrant a relocation of the Trinity Christian High School.
- The Naval Postgraduate School and Pacific Biological Laboratory should consider adaptation strategies to reduce its vulnerability including phased relocation or elevating of structures.

Biological Resources and Special-Status Species

Overview

The biological resources and special-status species component of the Existing Conditions and Issues Report expands upon and updates the existing conditions information contained in the existing subarea LUPs. Field surveys to verify study area existing conditions and evaluate potential for sensitive biological resources were conducted by EMC Planning Group in November and December 2015. Findings were summarized in a report found in Appendix B: *Existing Conditions Report: Biological Resources.* The report includes a summary of biological resource information contained in the existing General Plan and Land Use Plan; descriptions of current plant communities and wildlife habitats; and discussions of sensitive issues considered (special-status species, sensitive habitats, wildlife movement, and regulated trees).

The Land Cover Map included in the biological resources report displays available City-wide mapping data for major habitat types and other land covers provided in the *Biological Assessment for the City of Monterey* (Denise Duffy & Associates 2003). The biological resources report supplements the 2003 habitat mapping data with maps that identify current U.S. Fish and Wildlife Service (USFWS)-designated critical habitat areas for three special-status species, and National Oceanic and Atmospheric Administration data for Environmentally Sensitive Areas and other important biological resources.

Habitats

In the biological resources report, existing habitats are divided into five general categories:

- Central Dune Scrub and Coastal Foredune
- Monterey Pine Forests/Oak Woodlands
- Riparian and Wetland Habitats
- Shoreline and Marine Habitats
- Ornamental Landscaping

Environmentally Sensitive Habitat Areas (ESHAs)

California Coastal Act Section 30107.5 defines an ESHA as any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem, and which could be easily disturbed or degraded by human activities and developments. The Act protects ESHAs from habitat value disruption due to proposed development, and further protects adjacent buffer areas from habitat degradation.

Plant communities and wildlife habitats located within the study area that support special-status species, USFWS-designated critical habitat areas, and possibly additional sensitive habitats such as wetlands/waterways have potential to be considered ESHAs.

PLEASE NOTE THAT DUE TO THE RESOLUTION OF THE MAPPING IT WAS NOT POSSIBLE TO DO A QUANTITATIVE ANALYSIS OF EXISTING AND FUTURE VULNERABILITIES.

Existing Conditions

Natural Threats

- Coastal erosion
- Coastal flooding
- Temperature extremes
- Unpredictable precipitation
- Threat of wildfire
- Spread of invasive non-native species

Human Threats

- Development
- Habitat alteration, degradation, and destruction
- Human foot and vehicular traffic
- Pollution and toxins
- Human garbage bolstering predator populations
- Presence of domestic animals
- Small mammal control

2030 - 2100

Central Dune Scrub and Coastal Foredune: Erosion hazards and sea level rise are expected to significantly impact these habitats along the coastline, in addition to increased severity of flooding and tidal hazards.

Monterey Pine Forests/Oak Woodlands: Changes in precipitation and temperature patterns could lead to increased wildfires and spread of non-native invasive species in these habitats. Trees are also susceptible to disease and pests when stressed.

Riparian and Wetland Habitats: These habitats are expected to be altered by flooding hazards and salt water intrusion. These habitats are also sensitive to changes in temperature and seasonal shifts.

Shoreline and Marine : Ocean acidification and changes in water temperature alters species composition and ecosystem health. Erosion, sea level rise, and increased storm surges are also expected to impact this habitat. Seasonal shifts affects species associated with these habitats.

Ornamental Landscaping: Changes in precipitation/temperature patterns lead to increased wildfires and spread of non-native invasive species in these habitats. Erosion, flooding, and tidal hazards could also adversely impact eucalyptus stands.

Additional Information

Data Gaps

- Lack of current occurrence/distribution data within the study area for special-status species.
- Land cover map available data is at a large scale and is not refined to detailed info for study area.
- Lack of current density/distribution data of invasive plant species (such as iceplant and French broom) in sensitive habitats.
- Consistency of biological resource data and terminology between current EMC bio report, General Plan, and 5 LUPs.
- Lack of scientific data on how various species would be affected by different aspects of anticipated climate change.

Resource Monitoring Recommendations

- Support monitoring of specific climate variables that affect habitat location.
- Stay current on climate science related to precipitation, wildfire, and temperature changes.
- Understand relationship between habitats/elevation and duration of inundation.
- Support monitoring of adaptation impacts on the overall health of ecosystems, including hydrology, sensitive species habitats, and biodiversity.
- Support comprehensive monitoring programs and site-specific analyses to refine understanding and gauge effectiveness.
- Establish permanent plots to detect long-term vegetation changes at the community level.
- Create monitoring protocols specific to each species, habitat type, and management action.

Special-Status Wildlife

Species	Status	Threats
Coastal Dune Scrub and Coastal Foredune:		
Western snowy plover *(Charadrius alexandrinus nivosus)*	FT/SSC	Dune erosion, loss of early successional dune habitat, predators, trampling due to human foot and vehicular traffic, habitat loss, human disturbance, habitat degradation, invasive exotic plants, changing seasonal weather patterns disrupting life-cycle
Smith's blue butterfly *(Euphilotes enoptes smithi)*	FE/--	Dune erosion, human disturbance, habitat loss or degradation, invasive exotic plants, changing seasonal weather patterns disrupting life-cycle
Burrowing owl *(Athene cunicularia)*	--/SSC	Habitat loss, small mammal control, pesticides, predation, human disturbance, changing seasonal weather patterns disrupting life-cycle
Black legless lizard *(Anniella pulchra nigra)*	--/SSC	Habitat loss and degradation, predation, reproductive issues due to changes in temperature
Coast horned lizard *(Phrynosoma blainvillii)*	--/SSC	Habitat loss and degradation, predation, reproductive issues due to changes in temperature
Silvery legless lizard *(Anniella pulchra pulchra)*	--/SSC	Habitat loss and degradation, predation, reproductive issues due to changes in temperature
Monterey Pine Forests/Oak Woodlands:		
Monterey dusky-footed woodrat *(Neotoma fuscipes luciana)*	--/SSC	Habitat loss and fragmentation, small mammal control, introduced predators, toxins
Riparian and Wetland Habitats:		
Tricolored blackbird (*Agelaius tricolor*)	--/SSC	Habitat loss, introduced predators, salt water intrusion, spread of diseases due to temperature changes, changing seasonal weather patterns disrupting life-cycle
Western pond turtle *(Emys marmorata)*	--/SSC	Habitat loss, introduced predators, toxins, water quality degradation, salt water intrusion, spread of disease and reproductive issues due to increase temperatures
Rocky Intertidal Zones:		
Southern sea otter (*Enhydra lutris nereis*)	FT/SFP	Habitat loss, human activity, oil spills, ocean acidification, toxins, plastic trash, ocean warming, sea level rise.
Ornamental Landscaping:		
Monarch butterfly (*Danaus plexippus*)	--/-- (local concern)	Habitat loss, toxins, loss of host plants and nectar plants, habitat degradation, changing seasonal weather patterns disrupting migratory and life-cycle patterns

Listing Status Codes:
Federal (USFWS)
FE – Listed as Endangered under the Federal Endangered Species Act.
FT – Listed as Threatened under the Federal Endangered Species Act.
State (CDFW)
SE – Listed as Endangered under the California Endangered Species Act.
ST – Listed as Threatened under the California Endangered Species Act.

Special-Status Plants

Species	Status	Habitat Requirements
Seaside bird's-beak *(Cordylanthus rigidus* ssp. *littoralis)*	--/SE/1B.1	Closed-cone coniferous forest, maritime chaparral, cismontane woodland, coastal dunes, and coastal scrub. Prefers sandy often disturbed sites; elevation 0-215m.
Pacific Grove clover *(Trifolium polyodon)*	--/SR/1B.1	Mesic sites in closed-cone coniferous forest, coastal prairie, meadows and seeps, and valley and foothill grassland; elevation 5-120m.
Robust spineflower *(Chorizanthe robusta* var. *robusta)*	FE/--/1B.1	Sandy or gravelly openings in cismontane woodland, coastal dunes, and coastal scrub; prefers sandy terraces and bluffs or loose sand; elevation 3-300m.
Yadon's rein orchid *(Piperia yadonii)*	FE/--/1B.1	Sandy sites in coastal bluff scrub, closed-cone coniferous forest, and maritime chaparral; elevation 10-510m.
Beach layia *(Layia carnosa)*	FE/SE/1B.1	Coastal dunes, on sparsely vegetated semi-stabilized dunes, usually behind foredunes; elevation 0-75m.
Coastal dunes milk-vetch *(Astragalus tener* var. *titi)*	FE/SE/1B.1	Coastal bluff scrub and coastal dunes. Prefers moist sandy depressions of bluffs or dunes along and near the ocean; elevation 1-50m.
Menzies' wallflower *(Erysimum menziesii)*	FE/SE/1B.1	Coastal dunes. Known only from Mendocino and Monterey Counties, localized on dunes and coastal strand; elevation 0-35m.
Monterey clover *(Trifolium trichocalyx)*	FE/SE/1B.1	Closed-cone coniferous forest, endemic to Monterey County. Prefers poorly drained, low nutrient soil underlain with hardpan soils; also occurs in openings and burned areas; elevation 120-205m.
Tidestrom's lupine *(Lupinus tidestromii)*	FE/SE/1B.1	Partially stabilized dunes, immediately near the ocean; elevation 0-3m.
Monterey gilia *(Gilia tenuiflora* ssp. *arenaria)*	FE/ST/1B.2	Maritime chaparral, cismontane woodland, coastal dunes, and coastal scrub; prefers sandy openings; elevation 0-45m.
Monterey spineflower *(Chorizanthe pungens* var. *pungens)*	FT/--/1B.2	Sandy openings in maritime chaparral, cismontane woodland, coastal dunes, coastal scrub, and valley and foothill grassland; elevation 3-450m.

SR - Listed as Rare under the California Endangered Species Act.
SC – Candidate for listing as Endangered or Threatened under the California Endangered Species Act.
SSC – Species of Special Concern.
SFP – Fully Protected species under the California Fish and Game Code.

CNPS Rare Plant Ranks and Threat Code Extensions
1B: Plants that are considered Rare, Threatened, or Endangered in California and elsewhere.
.1: Seriously endangered in California (over 80% of occurrences threatened/high degree and immediacy of threat).
.2: Fairly endangered in California (20-80% occurrences threatened).

Note: The above tables contain excerpted information from the *Existing Conditions Report: Biological Resources*. For additional information, please refer to Tables 1 and 2 in Section 4 of the report. Special-status species not expected to occur in the City of Monterey Coastal Zone are not included above.

Appendix B. Biological Resources