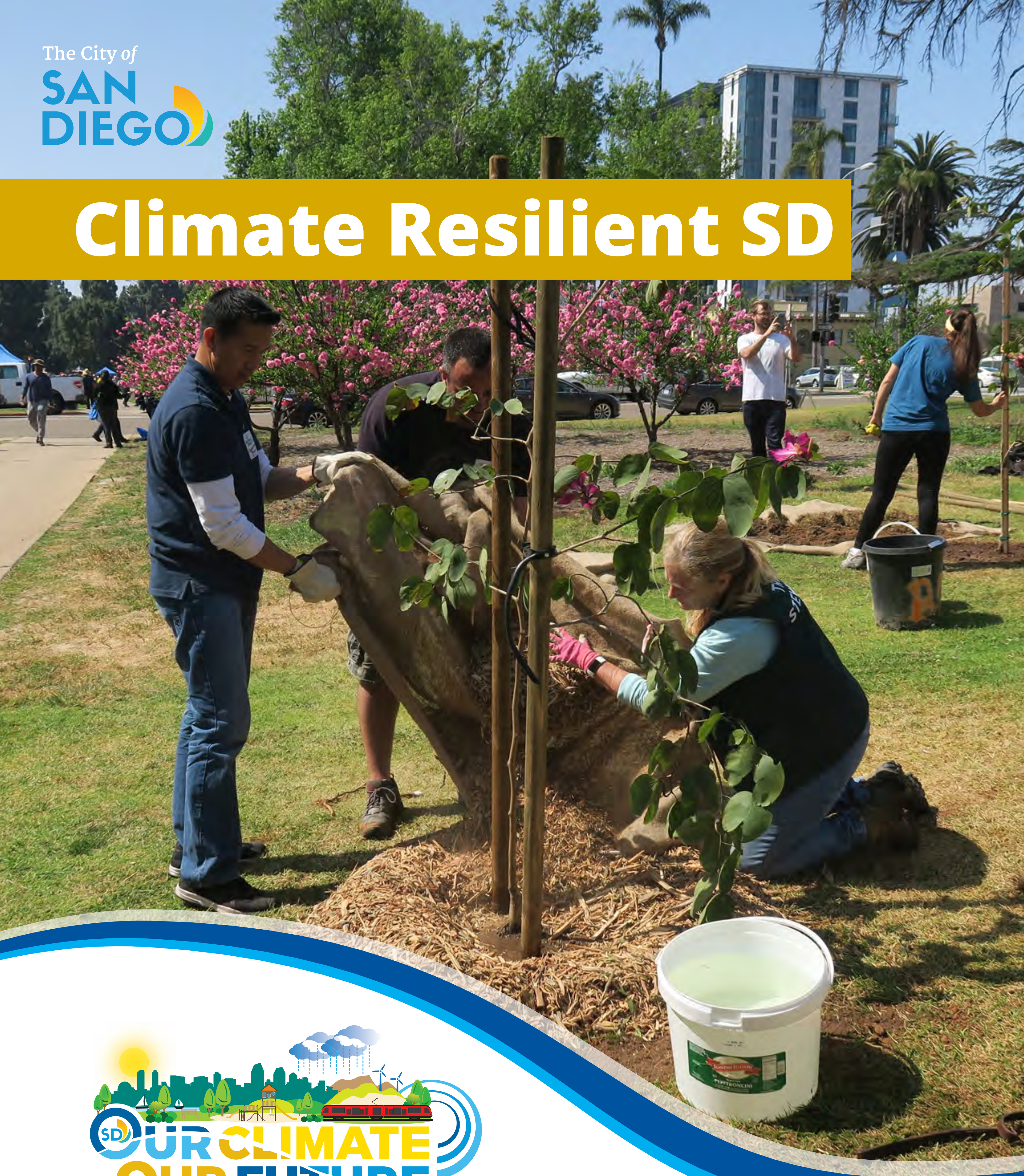
The City of SAN DIEGO

Climate Resilient SD



OUR CLIMATE OUR FUTURE

Climate Resilient San Diego

Letter from the Mayor:

Over the past two years of the COVID-19 pandemic, San Diego's communities have shown what it means to be resilient. Our residents and businesses have shown up for each other during these difficult times, we've adapted to changing conditions and environments, and figured out new ways of doing things. Now, as the impacts of climate change like wildfires and extreme heat intensify, we have an opportunity to harness this same resilience to create a safer, healthier, and more prosperous city for all of us.

Climate Resilient SD will serve as the City's comprehensive plan to prepare for and respond to climate change hazards that threaten our communities, including wildfires, drought, extreme heat, and flooding. As our country has witnessed in recent months, extreme weather driven by a changing climate can have devastating effects. While these threats aren't new to San Diego, science tells us that climate change is making these events more frequent and intense. The cost of inaction would be far greater than investing in our future.

Historically underserved communities are already experiencing the greatest impacts of climate change. Pursuing environmental justice requires that we acknowledge these disparities and focus our efforts in frontline communities. Prioritizing our actions and investments to protect the most vulnerable communities and address longstanding inequities is a core focus of Climate Resilient SD.

This moment calls for a paradigm shift in how we build climate-ready communities. And while there will be challenges, there are also so many opportunities - to enhance San Diegans' quality of life, build more green spaces, harness the power of clean energy and accelerate the growth of our innovative cleantech economy to keep San Diego on the cutting edge.

Climate Resilient SD will uplift these people-centered solutions to ensure we can all thrive for generations to come. The strength San Diegans have shown in the face of recent adversity makes me certain of this: we are resilient, and together we can create a stronger San Diego.

Sincerely,

Todd Gloria

TODD GLORIA
Mayor
City of San Diego

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Todd Gloria

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Honoring the land's original stewards:

The City of San Diego acknowledges that we are on the traditional territory of the Kumeyaay, Luiseño, Cupeño and Cahuilla.

Today, the Kumeyaay people continue to maintain their political sovereignty and cultural traditions as vital members of the San Diego community. We are honored to share this space with them and we thank them for their stewardship.


Pure Water
San Diego


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1.0 Our Resilient City

A resilient San Diego that can adapt to, recover from and thrive under changing climate conditions

Our Resilient City

What is climate resilience for San Diego?

Resilience is the capacity to respond to and recover from climate change hazard events and trends and maintain essential services, while also providing new equitable opportunities for a thriving future.

Purpose

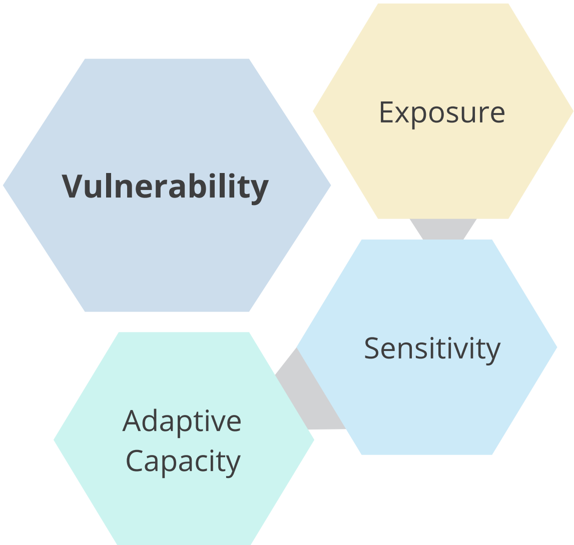
Climate Resilient SD is a framework for the City of San Diego to prepare for a changing climate that will:

- **Identify projects, policies and programs to improve daily life for San Diegans**
- **Prioritize, protect and uplift the City's most vulnerable communities**
- **Implement the Climate Action Plan Strategy 5 to comprehensively plan for a changing climate**
- **Implement State legislative requirements (Senate Bill 379)**

At its core, *Climate Resilient SD* is a plan for the people of the City of San Diego (City) to thrive. Climate change is already impacting our city and can be felt in the daily lives of residents. We experience days of extreme heat, have intense rainstorms that can leave streets flooded and breathe air impacted by wildfire smoke. These impacts are not felt equally across all our community members, with some communities experiencing the impacts more strongly, with fewer resources to prepare and respond. Socially vulnerable populations face disproportionate and unequal risk to climate change, including exposure to particulate air pollution, flooding, and extreme heat exposure[xxvi]. In recognition of this, *Climate Resilient SD* focuses on how we can protect those most vulnerable to climate change and improve the lives of the people in our city while preparing for a changing climate.

Climate Resilient SD is a comprehensive climate adaptation and resilience plan that addresses the four primary climate change-related hazards for the City: extreme heat, extreme rainfall or drought, wildfires and sea level rise. The level of impact these climate change hazards will have on the City's people, assets and resources was assessed through a detailed citywide Climate Change Hazard Vulnerability Assessment (Appendix B). This assessment considered exposure to the hazard, sensitivity to the hazard and to what extent the asset or resource could adapt to the hazard.

By identifying its more vulnerable communities, assets and resources, the City can implement adaptation strategies where they are most needed and use its resources most effectively. Adaptation strategies can lessen vulnerability by reducing exposure or sensitivity to climate change hazards, or by increasing their adaptive capacity, or ability to respond to the climate change hazard.



Climate adaptation and resiliency strategies can also focus on increasing community resilience, or the ability to bounce back—and forward—after a climate event. *Climate Resilient SD* is a framework for action that includes a range of adaptation strategies to minimize risk and increase the resilience of San Diego's people, assets, economy and natural resources to climate change.

MITIGATION VS. ADAPTATION

Climate change mitigation aims to reduce greenhouse gas emissions, slow down global warming, and avoid the worst potential impacts of climate change. This is the major goal of the City's Climate Action Plan.

The objective of climate change adaptation, on the other hand, is to reduce impacts from climate change-related hazards. *Climate Resilient SD* is the City's comprehensive adaptation and resilience plan that focuses on increasing local capacity to adapt, recover and thrive in changing climate.

Adaptation addresses a global problem: climate change. Yet, it also requires solutions that must consider local conditions, such as San Diego's social fabric, natural environment and local economy. A fundamental principle of *Climate Resilient SD* is that locally based, community grounded solutions will be the most effective in preparing San Diego for a changing climate. Public input—throughout the development of the plan and continuing into future implementation—is essential to shaping the plan and ensuring that the identified strategies address the community's needs.

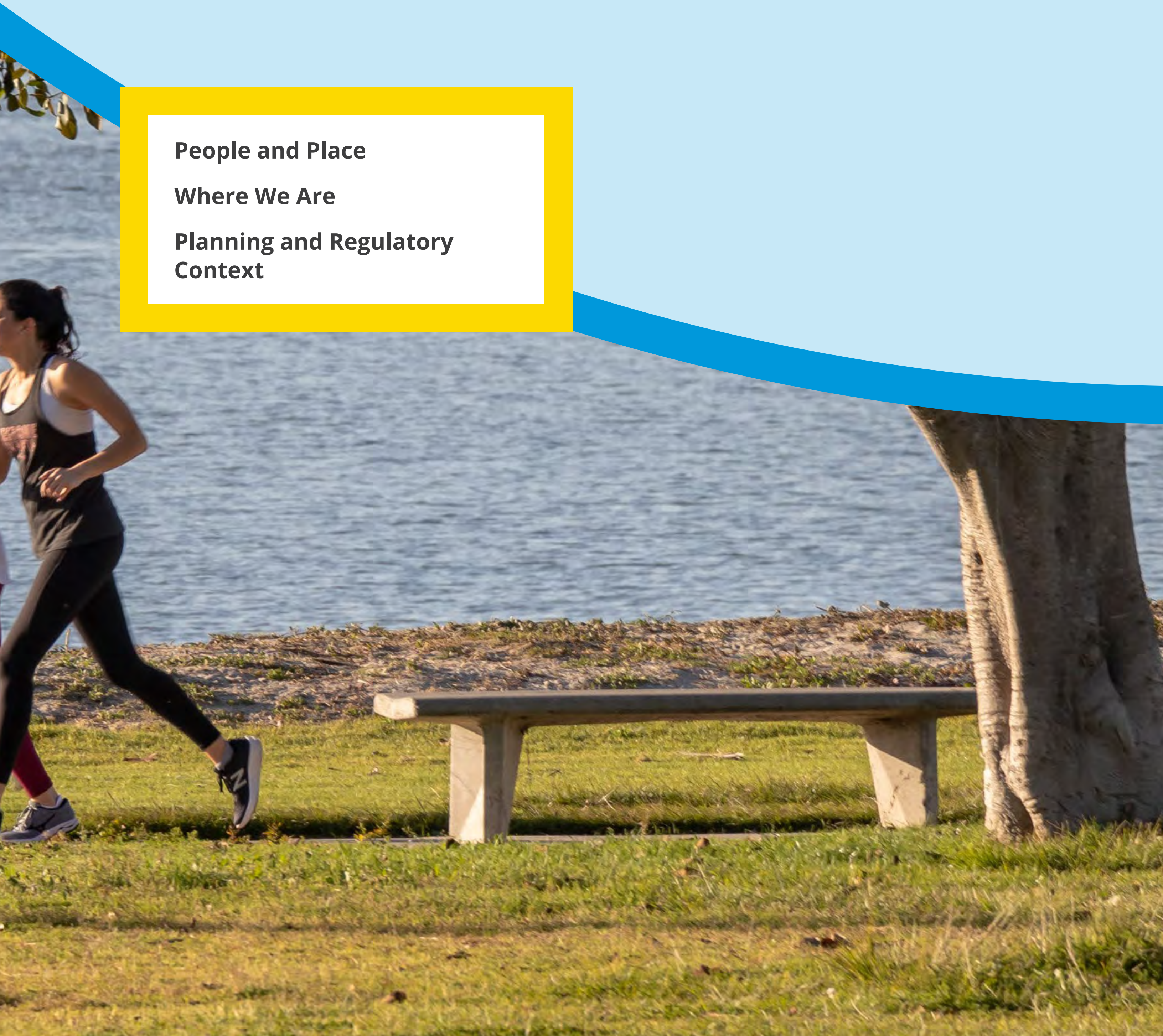
Climate Resilient SD looks at how climate change will impact San Diegans now, and into the future. The plan considers how to best plan for vibrant communities, how to protect the environment and how to prosper in the emerging economy. *Climate Resilient SD* includes a suite of goals, policies and strategies that have been shaped by public input. **Goals** reflect the broader vision for San Diego as we look to the future. **Policies** help to guide implementation actions and reflect the City's values and priorities. **Strategies** are implementation actions to prepare the City for climate change impacts and build more resilient communities. The strategies included are intended to provide flexibility in implementation, to allow the City adjust implementation with changing climate conditions and to prioritize action based on community needs. *Climate Resilient SD* is also intented to be a living document; its implementation shaped by continued community engagement and active involvement in plan implementation.

2.0 What We Have

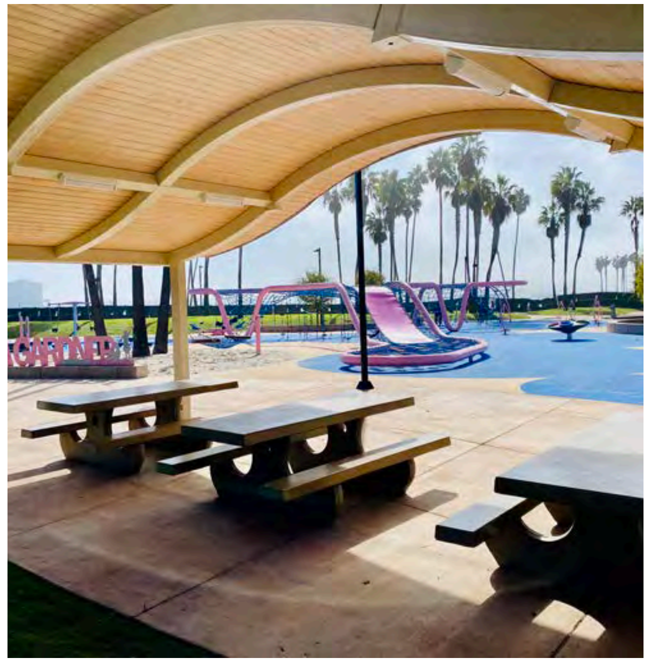
People and Place

Where We Are

Planning and Regulatory Context



What We Have



People and Place

The City of San Diego is well known for its wonderfully diverse people and communities and for its high quality of life. As the second largest city in California, San Diego is currently home to approximately 1.4 million people. The first inhabitants of this area were the Kumeyaay and Luiseño peoples, whose ancestors resided here long before the Spanish arrived in the 18th century and whose descendants are still here today.

Tribal History and Knowledge

The Kumeyaay and Luiseño people have inhabited the San Diego region throughout time. Historically, local tribes have had a deep connection with the land, with a hunting and gathering economy based on various plant resources. The tribes' knowledge and traditions have been passed down through generations, creating a deep understanding of the land and how to manage natural resources through fluctuations in climate conditions. Today, the tribes continue to have a strong relationship with the land and have completed plans that address climate change impacts to their land and communities.

Some examples of the exemplary work completed include:

- The Manzanita Band of the Kumeyaay Nation's Tribal Resilience Project is centered around the sacred relationship between the Kumeyaay and the 'snyaaw (Coast Live Oak) and investigates climate change scenarios with natural resources as the main focus.
- The La Jolla Band of Luiseño Indians' Adaptation Plan, a living document first created in 2019, has a strong focus on the relationship that tribal members have with the natural environment around them. The plan identifies climate change-related risks as well as actions that can be taken to adapt and safeguard the La Jolla Tribe's past, present, and future.

Local Native American tribes, like the Kumeyaay and Luiseño Bands, discussed above, are recognized as environmental specialists because of their deep understanding and knowledge of the environment. Their holistic approach to managing the land has enabled them to survive in the San Diego region over time. These local tribes have extensive knowledge regarding natural resource management by respecting Mother Earth and continuing to understand their role in maintaining a balance between traditional knowledge and a sustainable environment. Their viewpoints and guidance can provide great value to the region and should be given appropriate recognition.

CASE STUDY

Studying Climate Impacts on Cultural Resources within the California Coastal National Monument

The California Coastal National Monument (CCNM) provides an example of how climate change impacts can be considered in cultural resources management. The CCNM spans the entire length of the California coastline and includes many cultural resource sites. In order to learn more about the impacts that climate change is having on these sites, the Bureau of Land Management has partnered with Sonoma State University and the Society for California Archaeology to create a pilot project that will identify and study the impacts of climate change on coastal cultural resources located within the CCNM. This project will include volunteer field surveys and the preparation of a general workplan that other institutions can use for research grant proposals that study the impacts of climate change on the coast.

Source: National Park Services' Cultural Resources Climate Change Strategy document

Photo: California Coastal National Monument: State Park Lands adjacent to Cotoni-Coast Dairies public lands.

Photo Credit: Bureau of Land Management

Over the past few centuries, many other residents and visitors have also been drawn to enjoy the City's temperate climate. San Diego has grown from a settlement centered around Old Town into a City that boasts seventeen miles of coastline and a strong economy built on these four key base sectors: innovation and manufacturing, tourism, military, and international trade. Around thirty percent of the City's residents are Hispanic or Latinx, while roughly one-sixth are Asian and a little more than half are White. More than forty percent of San Diegans speak a language other than English at home. San Diego's temperate climate has made it possible for many rare, threatened and endangered plant and animal species to thrive.

The impacts of a changing climate present serious challenges to all who call San Diego home. Extreme heat, changes in precipitation, wildfire, and sea level rise pose risks to the City's residents, infrastructure, and natural environment. These climate hazards could also affect San Diego's economy, as key base industries such as tourism could be particularly impacted by climate change.

The City has taken steps to mitigate these impacts to preserve the natural diversity of our region, and to improve residents' quality of life. Several City plans already contain goals and policies that support the City's resilience efforts. Resilience goals and policies can be found in the City's General Plan, Climate Action Plan; Parks Master Plan; and Local Hazard Mitigation Plan.

Climate Resilient SD builds upon the City's existing policies to provide a comprehensive framework for action to mitigate the risks posed by climate change, and plan for a more resilient future.

PUBLIC FACILITIES, SERVICES AND SAFETY ELEMENT (SAFETY ELEMENT)

The Safety Element includes many climate related policies. It addresses facilities and services that are publicly managed and have a direct influence on the location of land uses, including Fire-Rescue, Police, Wastewater, Storm Water, Water Infrastructure, Waste Management, Libraries, Schools, Information Infrastructure, Disaster Preparedness and Seismic Safety.

Where We Are

CLIMATE TIMELINE

2003 Cedar Fire

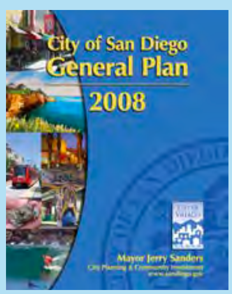
Destroyed over 280,000 acres and 2,820 buildings and killed 15 people. This was the largest wildfire in California history, as well as one of the deadliest and most destructive.

2005 Climate Protection Action Plan

The City of San Diego's first Climate Action Plan is approved in July 2005.

2007 Witch Creek/ Guejito Fire

Burned over 197,990 acres and 1,141 homes. These fires triggered the largest evacuation in County history. More than 500,000 people lived in the areas evacuated, 200,000 of them within the City of San Diego.

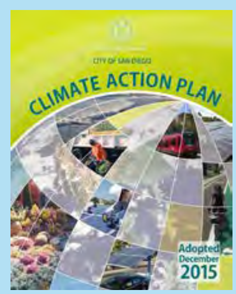


2008 Commitment to Update Climate Action Plan

The City of San Diego commits to updating and implementing its Climate Action Plan in its General Plan Update.

October 2015 Heat Wave

Over the course of several days, record high temperatures were reached in San Diego and other Southern California cities. This includes the top three warmest low temperatures in October dating back to 1875.



December 2015 Climate Action Plan Approved

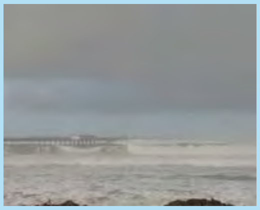
The City of San Diego's 2015 Climate Action Plan sets ambitious goals to reduce greenhouse gas emissions and wins unanimous approval from the City Council.

Winter 2016/2017 Rainfall

Wettest winter in over 122 years of record keeping for San Diego, leading to flooding and traffic problems across the region.

2017 Increase in Urban Tree Canopy

The City of San Diego's Climate Action Plan Annual Report reveals that the City's urban tree canopy cover has increased to 13% over the last 7 years, and the City adopts a Five Year Plan for its Urban Forestry Program to provide.



January 2019 King Tides

10 to 12 foot waves on January 18 lead to flooding in coastal communities, as well as causing severe damage to the Ocean Beach Pier, which had to be closed for repairs.

July 2019 AB691 State Land Sea Level Rise Vulnerability Assessment

The City of San Diego completed a state lands sea-level rise vulnerability assessment, evaluating the impacts of sea-level rise on its public trust lands and detailing a plan to address vulnerabilities and mitigate impacts.

August 2019 Emergency Stabilization

City of San Diego crews complete emergency construction to stabilize Cooks Crack Sea Cave, after weaknesses were identified in the cave, due in part to coastal erosion, that could affect the street above.

December 2019 Sea Level Rise Vulnerability Assessment

The City of San Diego releases its Sea Level Rise (SLR) Vulnerability Assessment. The SLR Vulnerability Assessment presents key findings on the exposure, sensitivity, and adaptive capacity of critical built, natural, and cultural assets to coastal hazards.

March 2020 Citywide Climate Hazard Vulnerability Assessment

The City of San Diego completes a comprehensive Climate Change Hazard Vulnerability Assessment that considers the potential risks and consequences of wildfire, extreme heat, sea level rise, and precipitation driven flooding to the City.

2021 San Diego Community Power

The City moves forward with San Diego Community Power, a Community Choice Aggregator, to help the City achieve 100% renewable energy.

Planning and Regulatory Context

Climate Resilient SD is shaped by existing laws and policies and establishes new policies intended to be relied upon moving forward with implementation to achieve the City's vision for an equitable and resilient City.

STATE

Senate Bill 379

California Senate Bill 379 (Senate Bill 379), mandates that each local jurisdiction review and update its General Plan Safety Element by January 1, 2022, to address applicable climate adaptation and resiliency strategies. Among other requirements, Senate Bill 379 requires a vulnerability assessment, a set of adaptation and resilience goals, policies and objectives, and a set of feasible implementation measures. *Climate Resilient SD* will include an update to the City's General Plan and meet the legislative requirements of Senate Bill 379.

Senate Bill 1035

California Senate Bill 1035 (Senate Bill 1035) requires that each local jurisdiction reviews and, if necessary, revises its General Plan Safety Element upon each revision of the General Plan Housing Element or local hazard mitigation plan. This must be done at least once every eight years to identify new information relating to flood and fire hazards and climate adaptation and resiliency strategies that were not available during the previous revision of the Safety Element. *Climate Resilient SD* will be updated regularly, at a minimum every five years, in compliance with Senate Bill 1035.

LOCAL

Climate Action Plan

The City of San Diego's 2015 Climate Action Plan calls for promoting the City's prosperity and quality of life by building communities that are resilient to climate change, while also recognizing some degree of climate change will occur while the City actively works to reduce and mitigate greenhouse gas (GHG) emissions. *Climate Resilient SD* implements Strategy 5 of the Climate Action Plan, which identifies the need for a standalone climate adaptation plan that integrates and builds upon the strategies and measures in the Climate Action Plan. The Climate Action Plan is concurrently being updated, providing the opportunity for the City to align its climate mitigation and climate adaptation efforts.

San Diego County Multi-Jurisdictional Hazard Mitigation Plan

The San Diego County Multi-Jurisdictional Hazard Mitigation Plan (Hazard Mitigation Plan) was last revised in 2018. The City of San Diego contributes to this plan by providing information on the City's critical facilities and potential exposures and losses related to climate change hazards. These climate change hazards include coastal storms and erosion, sea level rise, floods, rain-induced landslides, wildfire and non-climate-related hazards such as earthquakes, dam failures and tsunamis. The City's portion of this plan includes six hazard mitigation goals, along with objectives and prioritized action items to achieve them. The Hazard Mitigation Plan's mitigation goals, objectives and actions help inform the City's climate resiliency planning.

City of San Diego General Plan

The City of San Diego's General Plan is comprised of 10 elements that provide a comprehensive slate of citywide policies and further the City of Villages smart growth strategy for growth and development. One element of the General Plan is the Public Facilities, Services, and Safety Element (Safety Element), the purpose of which is to protect the community from unreasonable risks associated with the effects of geologic hazards, flooding, and wildland and urban fires. In 2018, the City's Safety Element was amended to include goals and policies that address the risk of wildfire in fire hazard severity zones.

GUIDANCE DOCUMENTS

- **The Governor's Office of Emergency Services' California Adaptation Planning Guide (APG) 2.0 (2020)** provides guidance for local jurisdictions to address climate change impacts. This latest version of the adaptation planning guide reflects current best practices; integrates recent updates to state plans, policies, programs and regulations; and ensures communities have guidance on using the best available science and information.

- **The Governor's Office of Planning and Research, California Natural Resources Agency, and California Energy Commission's California's Fourth Climate Change Assessment (2018)** was designed to address critical information gaps that decision-makers need at the state, regional and local levels to protect and build resilience of California's people and its infrastructure, natural systems, working lands and waters. This updated assessment draws on the best available science, and includes a wide-ranging body of technical reports, including comprehensive climate change scenarios at a scale suitable for illuminating regional vulnerabilities and localized adaptation strategies in California; datasets and tools that improve integration of observed and projected knowledge about climate change into decision-making; and recommendations and information to directly inform vulnerability assessments and adaptation strategies for California's energy sector, water resources and management, oceans and coasts, forests, wildfires, agriculture, biodiversity and habitat, and public health. The City has relied on the Fourth Climate Change Assessment, including its specific San Diego Region Report (discussed next), to reference the best available research on climate change as well as potential adaptation strategies.

- **The Governor's Office of Planning and Research, California Natural Resources Agency, and California Energy Commission's San Diego Region Report (2018)** was developed as part of a series of regional reports included in California's Fourth Climate Change Assessment, and includes an overview of climate science, specific strategies to adapt to climate impacts, and key research gaps needed to spur additional progress on safeguarding the San Diego region from climate change.

- **The California Natural Resources Agency's Safeguarding California (2018)** is the State's roadmap for state agencies to protect communities, infrastructure, services, and the natural environment from climate change impacts. This resource helps coordinate adaptation with state efforts and find examples of adaptation strategies.

- **The California Ocean Protection Council and California Natural Resources Agency's State of California Sea-Level Rise Guidance (2018)** provides guidance on the best available science on sea level rise projections and rates for California, a stepwise approach for state agencies and local governments to evaluate those projections and related hazard information in decision making, and preferred coastal adaptation approaches.

- **The California Coastal Commission's Sea Level Rise Policy Guidance (2018)** provides the best available science on sea level rise specific to California, paired with a recommended methodology for addressing sea level rise in Coastal Commission planning and regulatory actions, which informed the vulnerability assessment for sea level rise for the City.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3.0 What We Face

- Wildfire
- Heat
- Sea Level Rise & Coastal Flooding
- Coastal Erosion
- Extreme Rainfall & Droughts
- Climate Change Vulnerability Assessments

What We Face

Wildfire

Climate change will likely increase the key drivers of wildfires—high temperatures, dry conditions and flammable vegetation.[ii] Increases in the drivers of wildfires with climate change will lead to wildfires that occur more frequently[v] during a longer wildfire season,[vi] and burn longer and more intensely.[vii]

The Southwest United States, including California, is expected to experience increased drought with climate change.[iii] Historically, wildfires have been larger and more severe in areas with intensive drought stress.[i] These wildfires were also followed by higher tree mortality, which increases exposure to more future wildfires. Tree die-off in California has also reached historic highs in recent years due to pine beetles, heat, and drought, which are expected to increase with climate change and provide more fuel for fires.[iv]

In the San Diego region, wildfire risk is projected to increase, as is the risk of large catastrophic wildfires that arise from Santa Ana winds.[viii] However, changes in wildfire risks within the City limits is less certain due to uncertainties around urban development and resulting fuel characteristics. For example, there is some uncertainty in wildfire modeling due to different modeling approaches. The Cal-Adapt model assumes that increasing urban development will reduce vegetation cover and fire fuel availability and suggests that only less urbanized areas of San Diego will experience increased wildfire risk in the future. However, other studies predict a universal increase in wildfire risk for our region. San Diego should anticipate wildfire risk to be of equal or greater severity than in recent decades. Additionally, these larger and more frequent wildfires can cause increases in air pollution in the surrounding area and affect regional air quality.

Fire hazard severity zones for San Diego are shown in Figure 1.

Climate change will lead to wildfires that occur more frequently during a longer wildfire season and burn longer and more intensely.

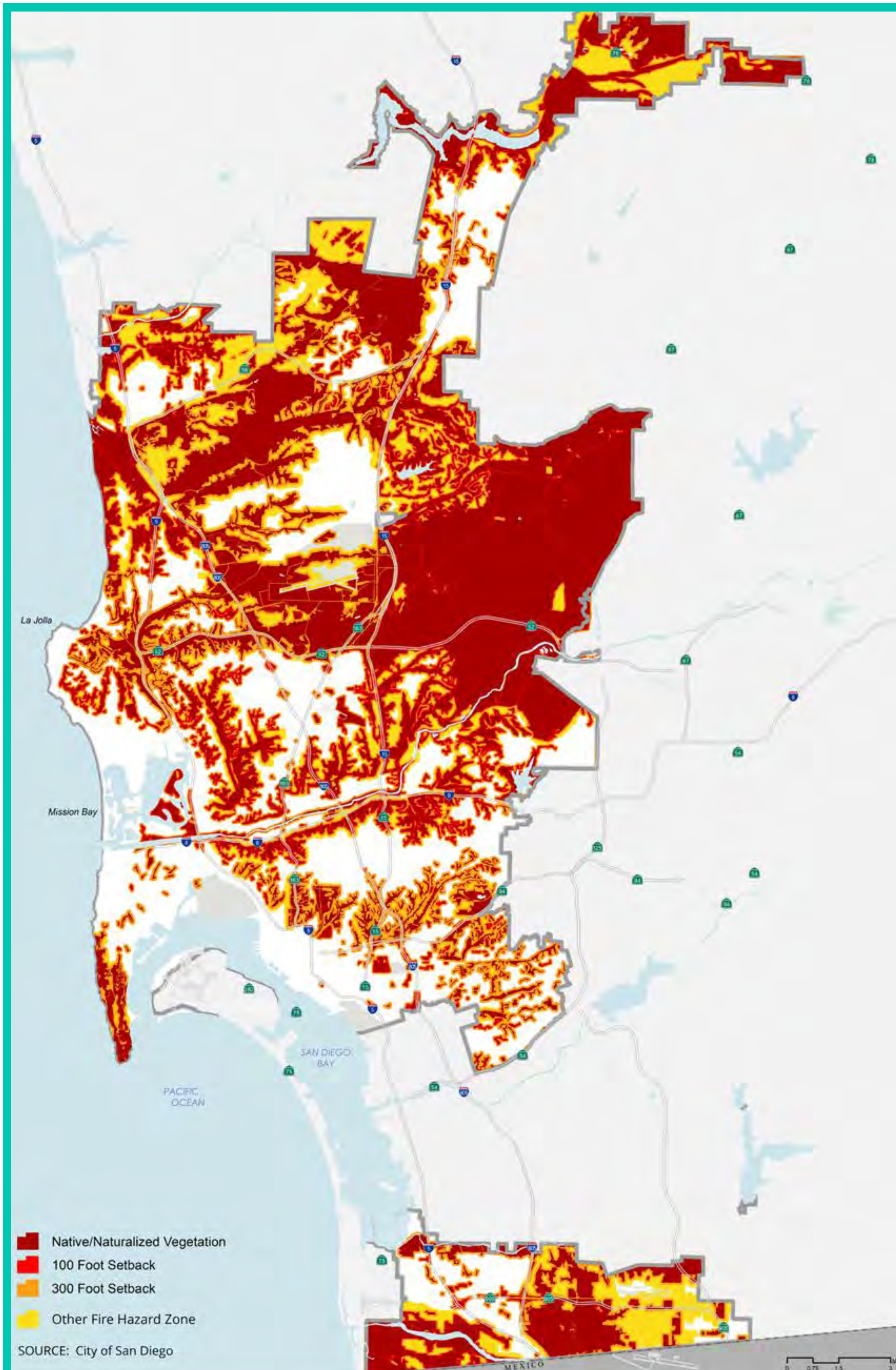

Figure 1: Fire Hazard and Brush Management Areas.

Additionally, under the high emissions scenario, the frequency and duration of warm nights are projected to increase substantially in San Diego by mid- to late-century. Warm nights pose a health risk, as they limit nighttime cooling and physiological recovery during heat waves and prolong the period over which heat-driven negative health outcomes can take place[ix].

San Diego routinely experiences hot summer days. "Extreme heat" is defined as a day with a maximum temperature exceeding 93.1°F.[1] In the past,[2] the City has experienced approximately four of these extreme heat days per year. The City, historically, has not been prone to many heat waves, with an average of only one heat wave[3] every other year and an average maximum of 2.5 consecutive extreme heat days per year.

Daily minimum temperatures, which generally represent the nighttime low temperature, are important for allowing people and infrastructure to cool off before the start of another day. Historically, the annual average daily minimum temperature for the City has been 52.9°F. Warm nights in San Diego occur when the daily minimum temperature exceeds 67.9°F[4]. There typically has been approximately four warm nights per year in the City, generally in August and September.

Heat

San Diego is known for its pleasant temperatures. In the past, extreme highs (93°F) have only occurred about four days per year. However, those pleasant temperatures are projected to change. By the 2080s, each year could include up to a month with daily highs over 93°F.

As shown in Figure 2, under the high emissions scenario, by mid-century, heat waves could be occurring three to five times more frequently, and each heat wave could drag out for more than twice as many days.

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[1] More specifically, an extreme heat day is defined as a day in April through October when the maximum temperature exceeds the City of San Diego's 98th percentile of historical maximum temperatures between April 1 and Oct. 31 based on observed daily temperature data from 1961–1990. This threshold for extreme heat days is calculated to be 93.1°F. In other words, historically, this temperature was only exceeded in the City of San Diego two percent of all days.

[2] Between the years 1960-1990.

[3] Heat waves are defined as four-day events where daily maximum temperatures exceed 93.1°F.

[4] 67.9°F is the 98th percentile historical minimum temperature threshold.

WHAT ARE EMISSIONS SCENARIOS?

The main driver of human-caused climate change is our emissions of carbon dioxide and other greenhouse gases into the atmosphere. Greenhouse gases are named such because they trap heat in the atmosphere, causing it to warm over time. Atmospheric warming in turn leads to other changes throughout the earth's system. How much the climate changes in the future depends in large part on the amount of greenhouse gases we emit now and going forward. However, since our emissions of greenhouse gases depend on a variety of different social, political, and economic factors, we cannot be certain how they will change. But we can use best available science on what potential greenhouse gas emissions may be and use those scenarios to create future climate projections.

The Cal-Adapt tool shows outcomes for two different greenhouse gas scenarios: a high-emissions scenario in which greenhouse gas emissions continue to rise over the 21st century, and a low-emissions scenario in which greenhouse gas emissions level off around the middle of the 21st century and by the end of the century are lower than 1990 levels.

Source: Cal-Adapt (https://cal-adapt.org/resources/using-climate-projections/).

FUTURE CONDITIONS

Climate projections indicate San Diego will experience more frequent extreme heat days in the future (see Figure 3). By mid-century,[5] extreme heat days could increase to 11 days under a low emissions scenario and 15 days under a high emissions scenario. By the late century,[6] this could further increase to 16 days under the low emission scenario and 32 days under the high emission scenario.[x] Heat waves are also projected to increase in frequency,[xi] duration and magnitude,[xii] with San Diego projected to experience up to 1.4 more four-day heat waves annually by mid-century, and up to 4.2 more heat waves annually by late century.

As the daily maximum temperatures are projected to increase, so too are the daily minimum temperatures. This will mean warmer nights in San Diego. Under a high emissions scenario, daily minimum temperatures could be 8°F warmer at the end of the century than they are today. The annual number of warm nights is also projected to increase substantially. Warm night projections for San Diego are shown in Figure 4.

By mid-century, under the high emissions scenario, San Diego could experience between three weeks to slightly over a month of warm nights per year. By late century, under the high emissions scenario, the City could experience between a month to more than three and a half months of warm nights per year.

Daily minimum temperatures could be 8°F warmer at the end of the century than they are today.

[5] Between the years 2035-2064.

[6] Between the years 2070-2099.

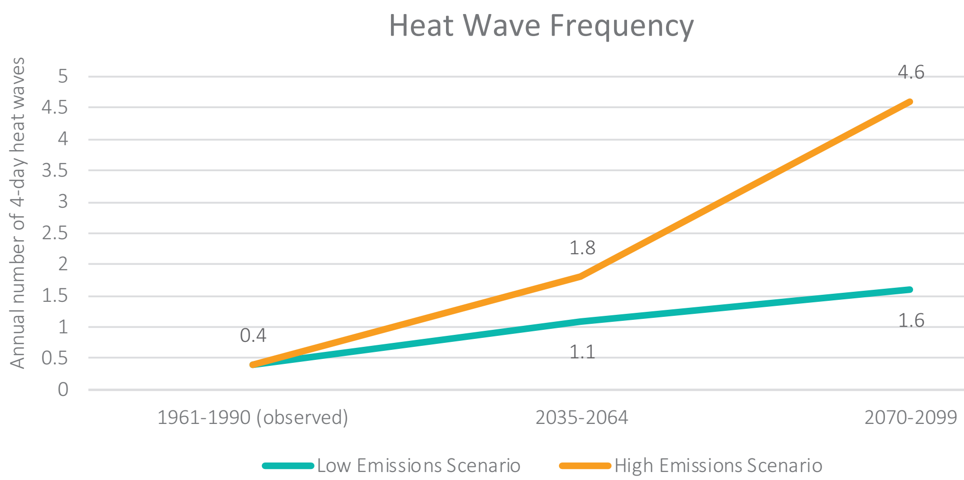

Figure 2: City of San Diego Heat Wave Frequency Projections.

Source: Cal-Adapt 2018.

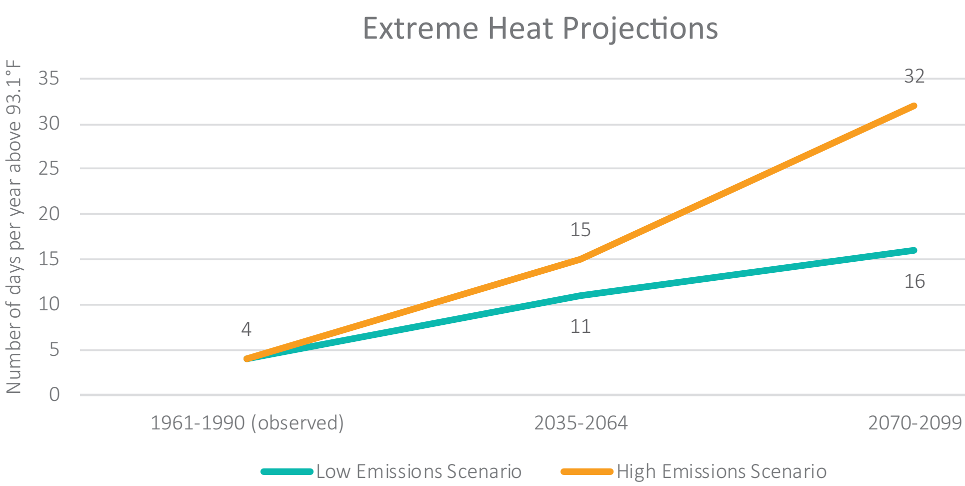

Figure 3: City of San Diego Extreme Heat Projections.

Source: Cal-Adapt 2018.

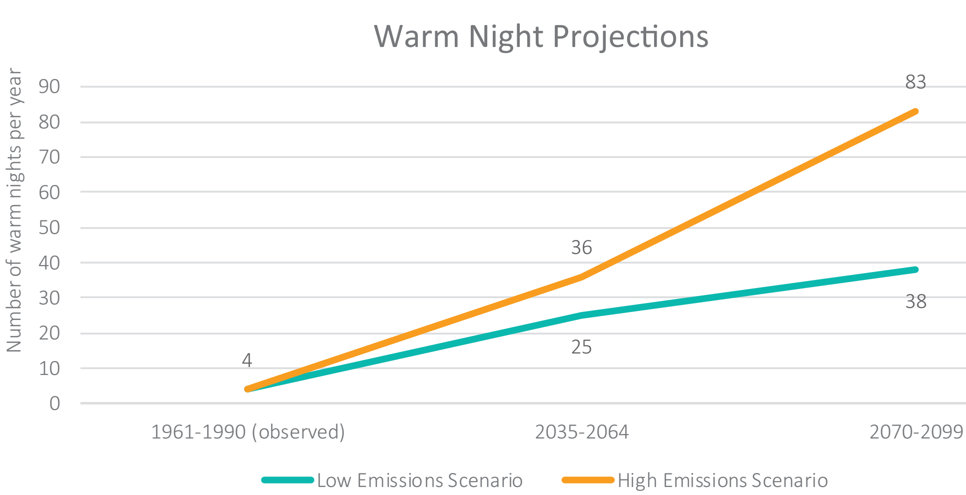

Figure 4: City of San Diego Warm Night Projections.

Source: Cal-Adapt 2018.

Sea Level Rise & Coastal Flooding

Sea levels rose 0.71 feet in San Diego during the 20th century (see Figure 5).[xiii] By the end of the 21st century, San Diego could experience another 3.6 to 10.2 feet of sea level rise. Coastal storms are projected to occur more frequently in the future, which will further exacerbate flooding along the coast.

SEA LEVEL RISE PROJECTIONS FOR SAN DIEGO*

2030: 0.6 to 1.1 feet
2050: 1.2-2.8 feet
2100: 3.6-10.2 feet

*Based on 2018 California Coastal Commission Sea Level Rise Policy Guidance

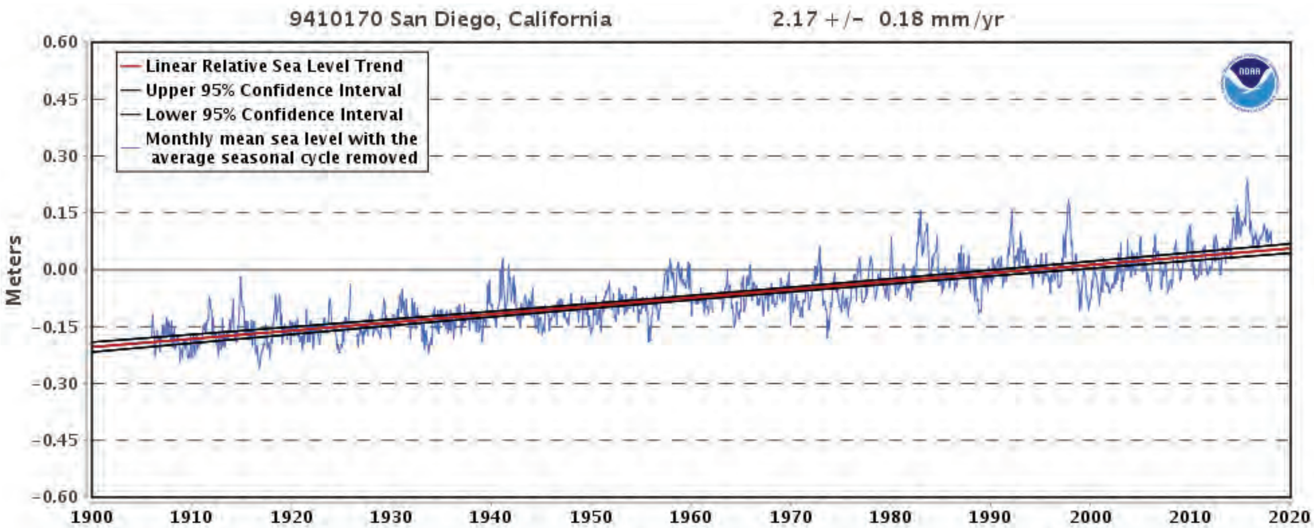

Figure 5: City of San Diego Historical Sea Level (Tide Gauge 9410170).

Source: NOAA 2018.

Over the past century, mean global sea level has risen approximately 1.7 millimeters per year, which has accelerated to a rate of 3.2 millimeters per year since 1993.[xiv] Data from the tide gauge in San Diego[7] suggests sea level here has risen approximately 2.17 millimeters per year, which is 32% higher than the global rate.[xv]

Sea levels in San Diego may rise between 1.2 to 2.8 feet by 2050, and 3.6 to 10.2 feet by 2100.[xvi] This range demonstrates the increasing uncertainty associated with estimating sea level rise in the long term, especially after 2050. The contribution of thermal expansion and melting of small glaciers to sea level rise is well researched. However, the impact of ice loss from large ice sheets melting in Greenland and Antarctica may soon become the primary contributor to sea level rise.[xvii] This rise in sea level is projected to accelerate towards the second half of the 21st century (see Figure 6).

The frequency of extreme flooding is also expected to increase under all projections of sea level rise. In addition, rising seas will magnify the occurrence of severe floods (such as the 500-year flood) along the Pacific Coast of the United States.[xviii] By elevating storm tide, sea level rise makes it easier for waves to surpass natural barriers, increasing the relative frequency of flooding along the coast.

[7] Measured between 1906 and 2017 for these calculations.

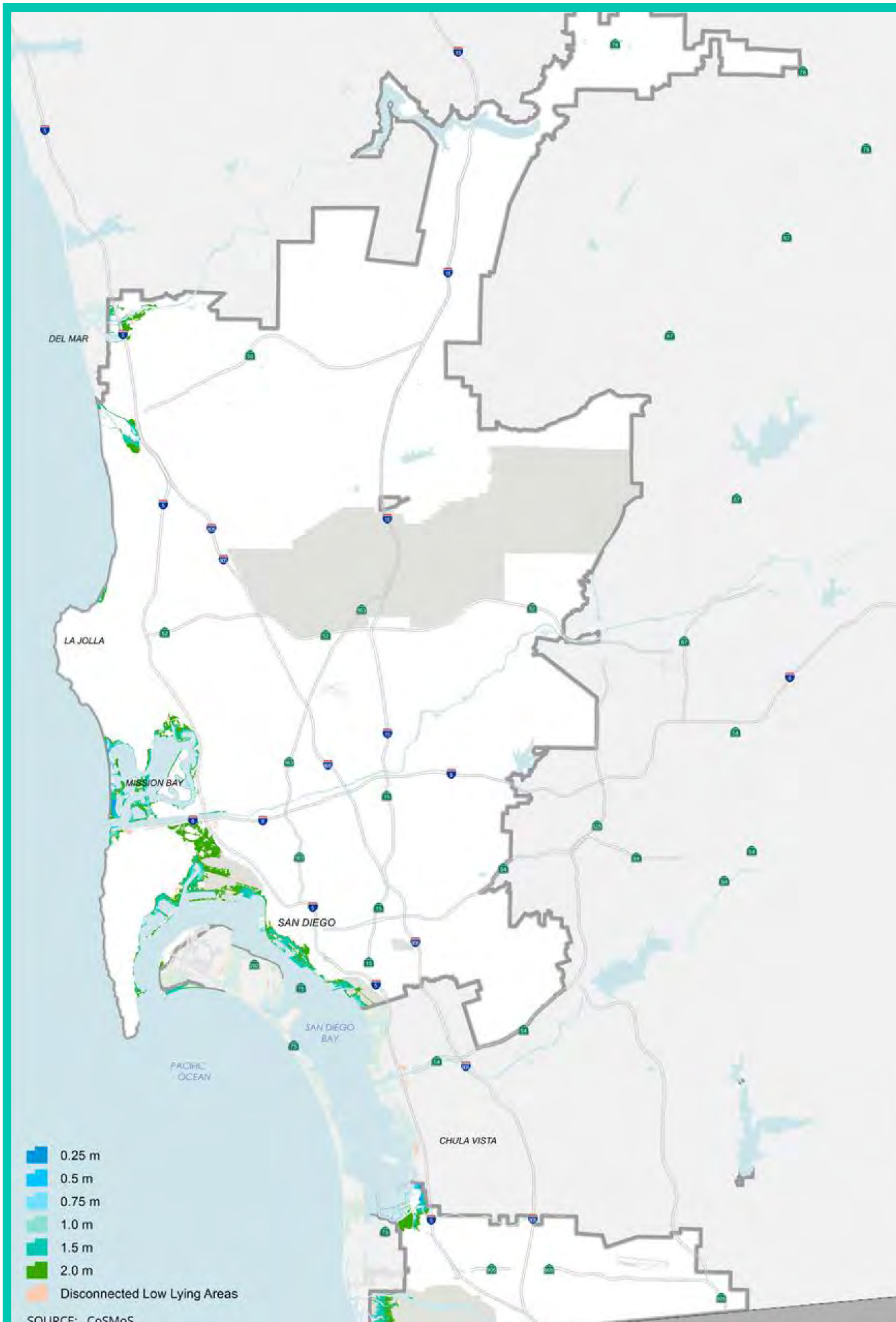

Figure 6. City of San Diego Daily Coastal Flooding.
(Flooding data obtained from USGS. Map was created 2021).

Coastal Erosion

Coastal erosion has long been an issue along the San Diego coastline. Locations such as Sunset Cliffs, La Jolla and Torrey Pines have experienced increased coastal erosion over time (Figure 7). With sea level rise and changes in storms, coastal erosion is expected to increase, though there is considerable uncertainty regarding where and when that may occur.

The relatively soft sandstone bluffs that are common along the San Diego coast are prone to erosion from waves and from storm water runoff. Sea level rise, combined with increased storm frequency, may accelerate beach and other coastal shoreline erosion.

Cliff erosion is likely to increase with sea level rise and heavier rainfall events, but modeling when and where can be difficult. Research from Scripps Institute of Oceanography indicates that cliffs cycle through periods of erosion and stability, meaning historic erosion rates are not always an accurate predictor of future erosion.[xix] Areas that have been stable for some time may start eroding, while areas that have been actively eroding may stabilize. It is hard to predict when and where cliff erosion may slow or accelerate.

Beach erosion is also likely to accelerate with sea level rise. While the City has previously conducted beach nourishment[xx], which involves placing additional sediment onto a beach to combat the effects of erosion, it is unlikely that historic rates of nourishment will be enough to stop future beach erosion. A recent study[xxi] found significant impacts to the shoreline will occur due to accelerated sea level rise, with 31% of beaches in Southern California lost by 2100 under a 3-foot sea level rise projection.

Figure 7: Coastal Erosion Assessment images for Hill Street to Guizot Street from 1993, 2003, and 2018.

Source: ICF 2018.

Extreme Rainfall & Droughts

Changes in precipitation patterns, which includes extreme rainfall and droughts, is a difficult variable for climate change models to project. More variability in rainfall from year to year is expected along with more intense transitions between droughts and extreme rainfall events.

California can experience wide swings in precipitation from drought years to El Niño years. But over the last 80 years,[8] the average rainfall in San Diego[9] has been about 10.13 inches annually.[xxii]

Annual average precipitation values from Cal-Adapt and other sources project only small changes[xxiii] in average annual rainfall (see Figure 8) for Southern California. However, there is expected to be greater variability in precipitation, and more intense transitions between dry and wet years. There may be more extreme dry years that are followed by extremely wet years, as recently occurred in 2015 to 2016 and 2016 to 2017.[xxiv] Extreme precipitation events, which historically occurred about every 25 years on average, are also expected to become 2.5 times more frequent in Southern California.[xxv] This implies that what we experience as extreme now will be considered the norm in the future. These heavier rainfall events will expand existing inland flooding areas (shown in Figure 9) and create new ones.

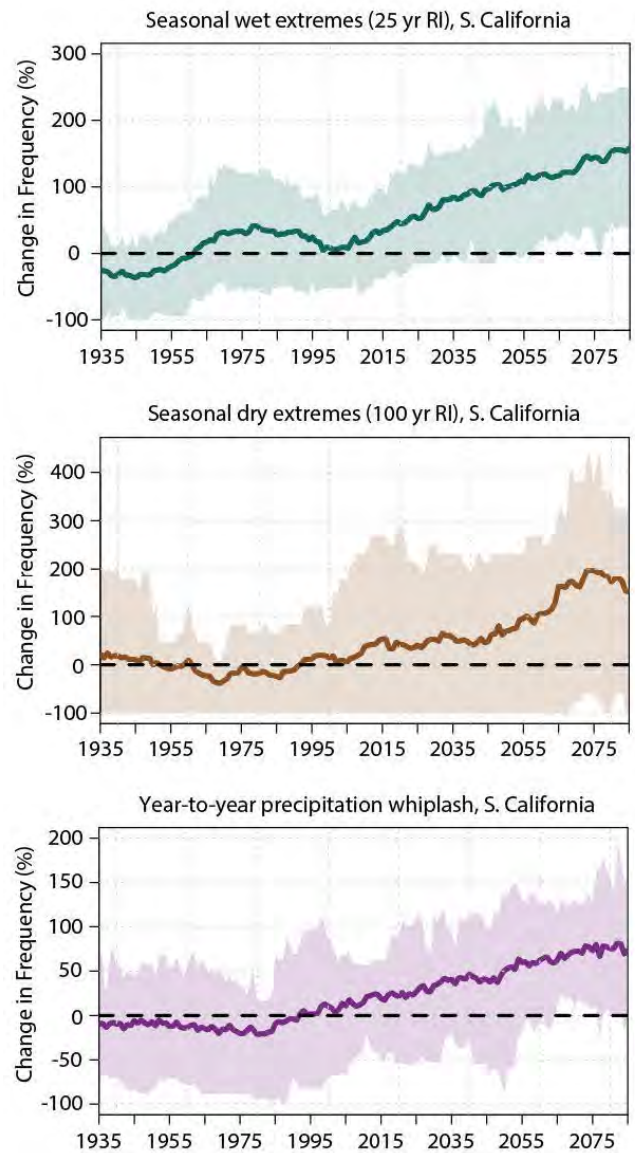

Figure 8: Precipitation Changes in Southern California.

Source: Swain et al. 2018.

Extreme precipitation events are also expected to become 2.5 times more frequent in Southern California.[1]

[8] Between 1939 and 2016.

[9] As recorded at San Diego International Airport.

Figure 9: City of San Diego Floodplains.

(FEMA Floodplain data, 2019).

Climate Change Vulnerability Assessments

Based on projected future conditions resulting from climate change, identifying San Diego's vulnerabilities to these conditions is essential to an informed and intentional approach to ensuring San Diego's resiliency. Several climate change vulnerability assessments have been completed, each of which has informed *Climate Resilient SD's* resiliency strategies.

COASTAL EROSION ASSESSMENT

The City of San Diego's Coastal Erosion Assessment, which was last updated in September 2018, monitors 71 sites along the City's 17-mile shoreline. These sites include bluff-top linear parks, bluff-top streets paralleling the coastal bluff and City streets that end at the bluff edge. A system of photographs, risk ratings and site notes for each site in the original assessment was designed to help the City identify and prioritize which coastal areas need remediation. The Coastal Erosion Assessment updates have monitored the conditions and changes of these sites over time.

The most recent update found that five sites showed obvious improvement in terms of risk, predominantly due to the City's efforts to mitigate signs of erosion and risks to pedestrians at these locations. Twelve of the sites showed evidence of increased erosion and increased risk to pedestrians. The most common problems identified at these sites included risks to pedestrian staircases, collapsing bluffs, potential weakening of sea-cave arches and lack of pedestrian access ways in some areas. See Appendix C, Coastal Erosion Assessment.

ASSEMBLY BILL 691 VULNERABILITY ASSESSMENT

The City of San Diego's AB 691 Vulnerability Assessment, which was completed in July 2019, presents a sea level rise (SLR) vulnerability assessment for the City of San Diego's granted lands in compliance with California Assembly Bill 691. In this report, the City analyzed the risks that sea level rise, storm surge and coastal erosion pose to City assets and public trust resources, such as parks, coastal habitats and coastal access points, located within granted lands in San Diego. Focused specifically on the granted lands, the assessment identifies vulnerable assets, estimates financial costs and identifies more than 30 potential mitigation and adaptation measures to reduce vulnerabilities.

Sea level rise and storm surge pose increasing risks of flooding and erosion to both City-owned and private resources and assets within San Diego's granted lands. Nearly all City asset types within granted lands, including bridges, historic and cultural resources, conservation areas and parks were ranked as highly vulnerable to sea level rise. Hotels and motels are the most vulnerable non-City assets on granted lands. Cost estimates show sea level rise could have a major impact to assets and resources if no adaptive measures are taken.

SEA LEVEL RISE VULNERABILITY ASSESSMENT

The City of San Diego's Sea Level Rise Vulnerability Assessment is a coastal focused assessment completed in December 2019. The Sea Level Rise Vulnerability Assessment assesses the vulnerability of critical built, natural and cultural assets to coastal hazards, including sea level rise, storm surge and coastal erosion. Vulnerability was scored using exposure, sensitivity and adaptive capacity as determining factors.

The assessment addressed vulnerabilities by City asset type as follows:

- **Public Safety Assets**: Lifeguard stations are highly vulnerable to sea level rise and coastal erosion. Many other assets, such as firetrucks, maintenance facilities and police stations are not exposed, and therefore not vulnerable to sea level rise or storm surge.
- **Water and Wastewater Assets:** Water and wastewater pipes, and water and wastewater pump stations are highly vulnerable to coastal erosion. In this assessment, distribution reservoirs, water and wastewater treatment plants and dams were not found to be exposed to either coastal erosion or sea level rise. Since the Vulnerability Assessment was completed, the City has completed additional analysis to further assess potential impact from coastal hazards to its infrastructure [10]. Further analysis found wastewater treatment plants to be highly vulnerable to coastal erosion.
- **Transportation and Stormwater Assets**: Bridges and outfalls are highly vulnerable to both coastal erosion and sea level rise. Drain pump stations are highly vulnerable to sea level rise and storm surge, but not exposed or impacted by coastal erosion.
- **Historic and Tribal Cultural Resources:** These are very sensitive assets and are highly vulnerable to both coastal erosion and sea level rise.
- **Open Space and Environmental Assets:** Recreation centers, community parks, conservation areas, beaches and sensitive habitat are highly vulnerable to sea level rise.

[10] Additional analysis has been completed by the City of San Diego since completion of the citywide Climate Change Hazard Vulnerability Assessment in February 2020. Please see Point Loma Wastewater Treatment Plant Coastal Erosion Assessment and Recommendation (January 2021), and Climate Change Action Plan, Special Studies Requirement VI of Order No. R9-2017-0007 (September 2020).

CLIMATE CHANGE VULNERABILITY ASSESSMENT

The City of San Diego's Climate Change Vulnerability Assessment is a citywide assessment completed in February 2020. It assesses the vulnerability of City asset types against four major climate change hazards: changes in the frequency and severity of wildfire; sea level rise and related coastal hazards; changes in precipitation; and extreme heat events. This report included a high-level vulnerability assessment of 31 critical asset types, using exposure, sensitivity and adaptive capacity to score the vulnerability of each asset type. The assessment also considered potential consequences of climate change hazards for each asset type.

Wildfire was identified as the primary climate change hazard in San Diego, as twenty asset types were found to be highly vulnerable to this hazard. However, all four hazards analyzed pose potential risks to City assets and services.

This assessment also addressed vulnerabilities by City asset type. Findings are summarized below and in Figure 10. For the full citywide vulnerability assessment, see Appendix B, Climate Change Hazard Vulnerability Assessment.

PUBLIC SAFETY ASSETS

- Lifeguard stations are highly vulnerable to coastal erosion and sea level rise, and police stations are highly vulnerable to wildfire. Other assets such as fire logistics and dispatch, and police patrol and specialty vehicles, are not exposed and not vulnerable to many of the assessed climate hazards.
- Damage to these assets could delay response of emergency services, and if some elements of the system are damaged or disrupted, other facilities may be called to serve a larger area.

WATER ASSETS

- Water and wastewater pipes and wastewater pump stations are highly vulnerable to coastal erosion; dams and wastewater pump stations are highly vulnerable to precipitation; and water pump stations are highly vulnerable to wildfire. Other assets such as distribution reservoirs and water treatment plants are not exposed, and not vulnerable to many of the assessed climate hazards. Additional analysis completed since the Vulnerability Assessment also found wastewater treatement plants to be highly vulnerable to coastal hazards [10].
- Damage to these assets could cause flooding, transportation delays or rerouting, and have negative consequences for human health, social equity, and the environment.

TRANSPORTATION AND STORM WATER ASSETS

- Bridges, major arterials, drain pump stations and outfalls are highly vulnerable to sea level rise; drain pump stations and outfalls are highly vulnerable to sea level rise with storm surge; bridges and outfalls are highly vulnerable to coastal erosion; drain pump stations and outfalls are highly vulnerable to precipitation; and airports, bridges, major arterials and drain pump stations are highly vulnerable to wildfire.
- Impacts to transportation assets could delay emergency vehicles and disrupt daily movement of goods and people, while impacts to storm water assets could exacerbate flooding.

OPEN SPACE ASSETS

- Community parks and beaches are highly vulnerable to sea level rise and to coastal erosion; community parks are highly vulnerable to wildfire; and open space is highly vulnerable to all four of the assessed climate hazards. Other assets, such as Miramar Landfill and CNG Fueling Station, are not exposed and not vulnerable to many of the assessed climate hazards.
- Damage to open space assets could cause habitat loss for many threatened and endangered species, and damage to built infrastructure could affect City services, human health and social equity.

ADDITIONAL ASSETS

- Recreation centers are highly vulnerable to sea level rise, and historical and tribal cultural and archaeological resources are highly vulnerable to all four of the assessed climate hazards. Other assets, such as libraries and City buildings, are not exposed and not vulnerable to many of the assessed climate hazards.
- Impacts to these assets could affect City services and damage historical and cultural resources.

Vulnerability of Critical Assets to Climate Change

The Vulnerability Assessment identified critical City asset types and analyzed their vulnerability to the climate change hazards. Medium and high vulnerability scores are outlined below. Low vulnerability scores were not included as they are considered to be of lesser concern at this time.

Sectors	Asset Types	Medium Vulnerability	High Vulnerability
Public Safety	Fire Stations	Wildfire	
	Police Stations		Wildfire
	Lifeguard Stations	Storm Surge, Wildfire, Precipitation	Sea Level Rise, Coastal Erosion
	Maintenance Facilities	Wildfire, Precipitation	
	Police Patrol and Specialty Vehicles	Wildfire	
	Other Public Safety	Sea Level Rise, Storm Surge	Wildfire
Water	Dams	Wildfire	Precipitation
	Water Pipes	Sea Level Rise, Storm Surge, Precipitation	Coastal Erosion
	Wastewater Pipes	Sea Level Rise, Storm Surge, Precipitation	Coastal Erosion
	Water Pump Stations	Extreme Heat, Precipitation	Wildfire
	Wastewater Pump Stations	Storm Surge	Coastal Erosion, Precipitation
	Distribution Reservoirs	Wildfire, Extreme Heat	
	Water Treatment Plants	Wildfire	
	Wastewater Treatment Plants	Wildfire, Extreme Heat	
Transportation and Storm Water	Airports	Extreme Heat	Wildfire
	Bridges	Storm Surge, Extreme Heat, Precipitation	Sea Level Rise, Coastal Erosion, Wildfire
	Major Arterials	Storm Surge, Coastal Erosion, Extreme Heat, Precipitation	Sea Level Rise, Wildfire
	Drain Pump Stations		Sea Level Rise, Storm Surge, Wildfire, Precipitation
	Outfalls	Wildfire, Extreme Heat	Sea Level Rise, Storm Surge, Coastal Erosion, Precipitation
	Levees	Wildfire, Precipitation	
Open Space and Environment	Conservation Areas/Open Space/Source Water Land		Sea Level Rise, Storm Surge, Coastal Erosion, Wildfire, Extreme Heat, Precipitation
	Community Parks	Storm Surge, Extreme Heat, Precipitation	Sea Level Rise, Coastal Erosion, Wildfire
	Miramar Landfill	Wildfire	
	Beaches	Storm Surge, Wildfire, Precipitation	Sea Level Rise, Coastal Erosion
Additional Assets	Recreation Centers	Wildfire, Extreme Heat, Precipitation	Sea Level Rise
	Libraries	Wildfire	
	City Buildings	Wildfire	
	Historical, Tribal Cultural, and Archaeological Resources	Extreme Heat	Sea Level Rise, Storm Surge, Coastal Erosion, Wildfire, Precipitation

Coastal Hazards:
Sea Level Rise · Storm Surge · Coastal Erosion · Wildfire · Extreme Heat · Precipitation

Figure 10: City Asset Vulnerability to Climate Hazards [11].

[11] Additional analysis has been completed by the City of San Diego since completion of the citywide Climate Change Hazard Vulnerability Assessment in February 2020. This analysis found the Point Loma Wastewater Treatment Plant to be highly vulnerable to coastal erosion. Please see Point Loma Wastewater Treatment Plant Coastal Erosion Assessment and Recommendation (January 2021), and Climate Change Action Plan, Special Studies Requirement VI of Order No. R9-2017-0007 (September 2020).

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COLOMBIA

4.0 How We Will Thrive

Connected & Informed Communities

Resilient & Equitable City

Historic & Tribal Cultural Resources

Thriving Natural Environments

Critical City Services

Implementation Framework

How We Will Thrive

Climate change is already impacting San Diegans; we experience wildfires, heat waves and flooded streets. These climate change related events will continue and intensify in the coming years. By taking action now and planning for a resilient San Diego, we can reduce risk and enhance our climate change readiness. As we plan for the effects of climate change, the City will ensure that communities are connected and informed about how climate change will impact their daily lives. Decisions must be inclusive, equitable and based on the best available science. Historic and tribal cultural resources need to be protected, and natural environments should be conserved and enhanced. Critical City services must also be maintained to protect public health and safety and support our daily activities.

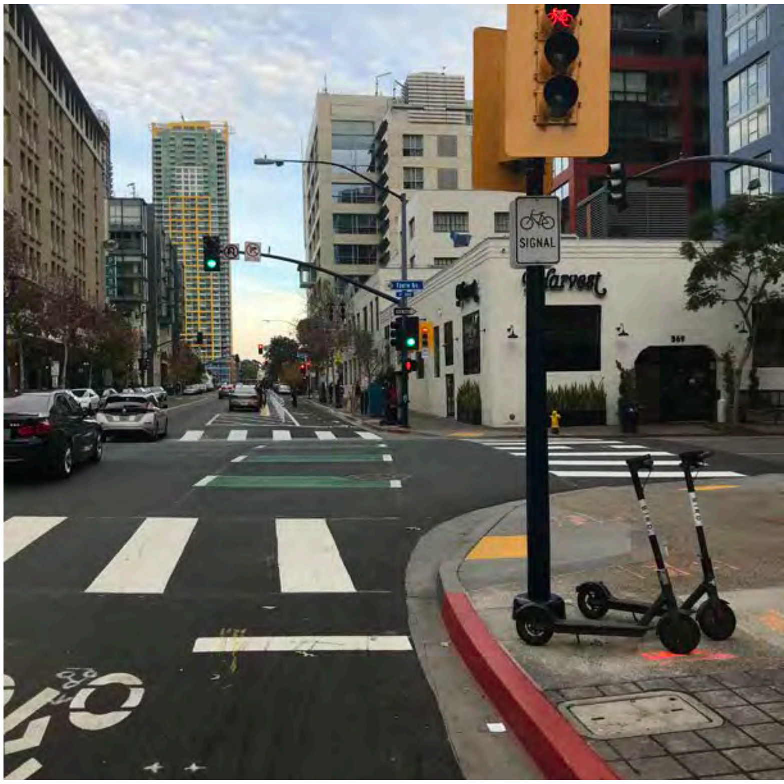
CLIMATE RESILIENT SD HAS FIVE MAIN GOALS

1. Ensure communities are connected and informed to be best prepared for climate change
2. Plan for and build a resilient and equitable city
3. Safeguard, preserve and protect historic and tribal cultural resources from the effects of climate change
4. Support and prioritize thriving natural environments and enhance adaptability
5. Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards

The goals reflect the broader vision for San Diego as we plan for a changing climate and what a resilient San Diego should look like. Each goal includes supporting policies that reflect our values and priorities and help guide the implementation of the adaptation and resilience strategies. The adaptation and resilience strategies are a suite of actions that will bring us closer to making these five goals a reality. These strategies support and expand upon existing efforts already undertaken by the City to prepare for a changing climate, such as wildfire preparedness, increasing urban tree canopy and increasing our protected habitat areas. The adaptation and resilience strategies will build a more climate ready San Diego, improving our ability to not just bounce back from climate change events, such as heat waves or wildfire, but to bounce forward, to a greener, more equitable and thriving future.

Successful implementation of these strategies will require continued community involvement, working closely with community members to identify community needs and opportunities, especially in our underserved communities.

Successful implementation will also leverage the additional benefits provided by many of these strategies. These additional benefits - or core benefits - are services and benefits provided by adaptation strategies beyond risk mitigation. For example, increasing green spaces in areas subject to flooding helps to lower the risk of flooding, but also improves air quality, provides recreational opportunities and provides additional habitat for plants and animals. Adaptation strategies that have core benefits can be inherently better for communities and for the City overall. Along with the effectiveness and cost of strategies, core benefits should be used to prioritize strategy implementation. More detailed information on each strategy, including its core benefits, cost, implementation timeframe and the climate change hazards it addresses, is contained in Appendix A, Adaptation and Resilience Strategies.



Connected & Informed Communities

Goal: Ensure communities are connected and informed to be best prepared for climate change.

Community preparedness is critical for protection of physical safety, social cohesion and continued economic vitality. In order for communities to be most prepared for a changing climate, people need to have knowledge of how a climate change hazard might affect their daily life, awareness of resources available to them and ability to access necessary critical services. A more informed community will be better prepared to respond to and recover from climate change events. Further, tighter knit communities with closer social connections between neighbors will be better able to disseminate information, assist each other in accessing resources, and bounce back from climate change impacts. A strong social fabric builds cohesiveness and strength in community response. The City aims to help empower and support community connection building and serve as a resource for information and services.

When participants in the first community workshop were asked, "What solutions would benefit you and your community the most?," two of the top responses were related to education—citing the need for more educational resources on climate change impacts, and climate change education for youth. The City's community based organization partners in this engagement effort also reported similar feedback on the need for more educational information on climate change impacts.

Climate change hazards do not abide by jurisdictional boundaries. Climate resilience will require collaboration between the City and its regional partners. Through collaborating with other cities and the County, local universities, community groups, non-profits, tribal nations and regional organizations, the City will be able to both contribute to and benefit from regional knowledge and resources. Collaboration, communication and education will be key pillars in achieving local and regional climate resilience.

Policy CI-1: Provide easily accessible education resources and grow community awareness of climate change.

Policy CI-2: Enhance ability of communities to prepare for, respond to and recover from climate change impacts.

Policy CI-3: Strengthen the City's regional partnerships to leverage and expand available resources for climate resilient actions.

Policy CI-4: Collaborate with arts, cultural and creative sector to increase community awareness of and engagement with climate planning.

Policy CI-1: Provide easily accessible education resources and grow community awareness of climate change.

- Develop a comprehensive climate adaptation community outreach program. Conduct community outreach through various methods and in multiple languages to share climate change and climate adaptation information and resources with communities.
- Increase investment in a citywide public outreach and education campaign to increase the public awareness of water quality matters.

Policy CI-2: Enhance ability of communities to prepare for, respond to, and recover from climate change impacts.

- Provide grid resilience services through grid-integrated vehicle programs.
- Develop resilient design guidelines or modify zoning, permitting processes, and standards to support smart, sustainable, resilient development and reduce exposure to climate change hazards.
- Hold community trainings for emergency response and preparedness.
- Expand and amplify wayfinding and public outreach campaigns for wildfire response. Support community preparedness with focused public outreach. Consider needs of those without car access or with additional accessibility requirements.

Policy CI-3: Strengthen the City's regional partnerships to leverage and expand available resources for climate resilient actions.

- Coordinate with local transit agencies for resilient public transit systems upgrades.
- Collaborate with climate science experts on local climate change impacts, mitigation and adaptation to inform public policy decisions.
- Build regional resilience through collaboration with local, regional and State agencies as well as community based organizatations and non-profits.

Policy CI-4: Collaborate with arts, cultural and creative sector to increase community awareness of and engagement with climate planning.

- Explore varied approaches and platforms to engage people in discourse, learning and actions around climate change and the environment.
- Develop a cultural plan that connects arts and culture with City sustainability and resiliency goals.

Resilient & Equitable City

Goal: Plan for and build a resilient and equitable City.

To build a truly resilient San Diego, existing inequities must be addressed, and an equitable plan for prioritizing investments must be developed. Integrating social equity across City operations, centering racial and social justice practices in outreach and strengthening community partnerships are critical to achieving these goals. The impacts of climate change will not be felt equally by all communities, as some are more vulnerable than others. Historic disinvestments and unjust systems have resulted in some communities having access to fewer resources and being disproportionately impacted by climate change. These communities will face greater exposure to climate change hazards and experience climate change related impacts first and worst. By supporting and uplifting the most vulnerable populations and ensuring that they are safe and healthy despite potential climate change impacts, we can build a stronger, more resilient and equitable City.

Through the development of the City's Climate Equity Index (see Figure 11), communities most vulnerable to climate change have been identified. The Climate Equity Index measures the level of access to opportunity that residents have and assesses the degree of potential impact climate change may have on these areas. Thirty-five indicators, such as asthma rates, healthy food access, tree coverage and median income, were identified to assess access to opportunity. Census tracts with a score of very low, low, or moderate access to opportunity are referred to as Communities of Concern. Because the needs are greater in Communities of Concern, implementing climate adaptation and resilience strategies should be prioritized in these communities. In addition to other factors, resiliency strategies have been identified that deliver direct benefits, generate multiple benefits and build capacity within these communities.

Policy RE-1: Prioritize resilience investments and implementation of strategies in Communities of Concern, as identified in the Climate Equity Index.

Policy RE-2: Foster vibrant, healthy and sustainable communities.

Policy RE-3: Prioritize strategies with multiple benefits that increase the adaptive capacity of the City's most vulnerable communities.

Policy RE-4: Deepen community partnerships to support greater community involvement in resilience action and plan implementation.

Policy RE-5: Ensure vulnerable communities have resources necessary to respond to climate change impacts.

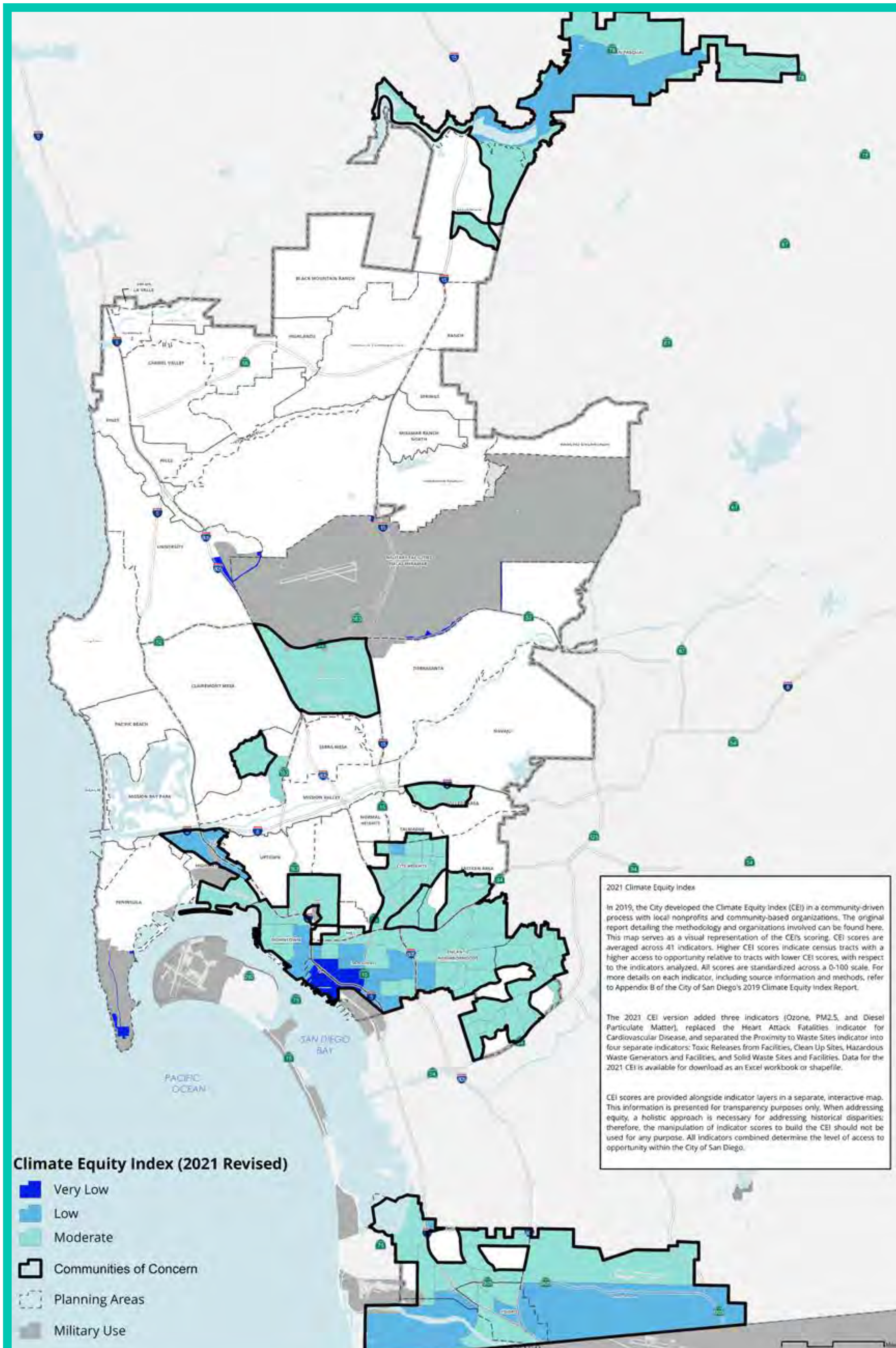


Figure 11: Climate Equity Index.

Policy RE-1: Prioritize resilience investments and implementation of strategies in Communities of Concern, as identified in the Climate Equity Index.

- Utilize Climate Equity Fund and other funding sources to direct investments to resilience projects in Communities of Concern
- Ensure Capital Improvement Program integrates climate resilience and equity considerations into the budgeting and project selection process
- Work with Office of Race and Equity to ensure need and priorities of residents in Communities of Concern are reflected in plan implementation

Policy RE-2: Foster vibrant, healthy and sustainable communities.

- Support expansion and management of an active transportation network. Provide safe, accessible active transportation infrastructure.
- Explore opportunities and programs to increase access to healthy food markets, farmer's markets and other local food networks, particularly for low income residents and families.

Example of Moss Stop. Green bus stops can make public transit systems more climate ready, helping to reduce urban heat, improve air quality, and absorb rainwater.

Photo source: Clear Channel UK

- Increase access to parks and open space for all San Diegans. Increase overall shaded area at park spaces. Natural shade from trees shall be prioritized over artificial shade structures, whenever feasible.
- Incentivize installation of cool roofs and green roofs.
- Utilize the Urban Heat Vulnerability Index to help inform implementation of adaptation strategies to address extreme heat events and identify priority areas for cooling interventions.

Policy RE-3: Prioritize strategies with multiple benefits that increase the adaptive capacity of the City's most vulnerable communities.

- Collaborate with the Air Pollution Control District (APCD) to implement the Community Emissions Reduction Plan (CERP) and AB 617.
- Develop an urban greening program to promote expanded green spaces in urban areas. The program should facilitate greening of City buildings and encourage private development to include green features through policy development or incentive programs.
- Establish a community garden program to convert vacant lots, rooftops or other available space to public community gardens.

Policy RE-4: Deepen community partnerships to support greater community involvement in resilience action and plan implementation.

- Cultivate leadership and environmental stewardship in San Diego's youth. Consider partnerships with local schools and universities, focused internship programs and leadership opportunities.
- Create principles for meaningful, equitable community engagement. Identify ways to remove barriers to participation.
- Promote water conservation, water reuse and best management practices in local businesses and industry.

Policy RE-5: Ensure vulnerable communities have resources necessary to respond to climate change impacts.

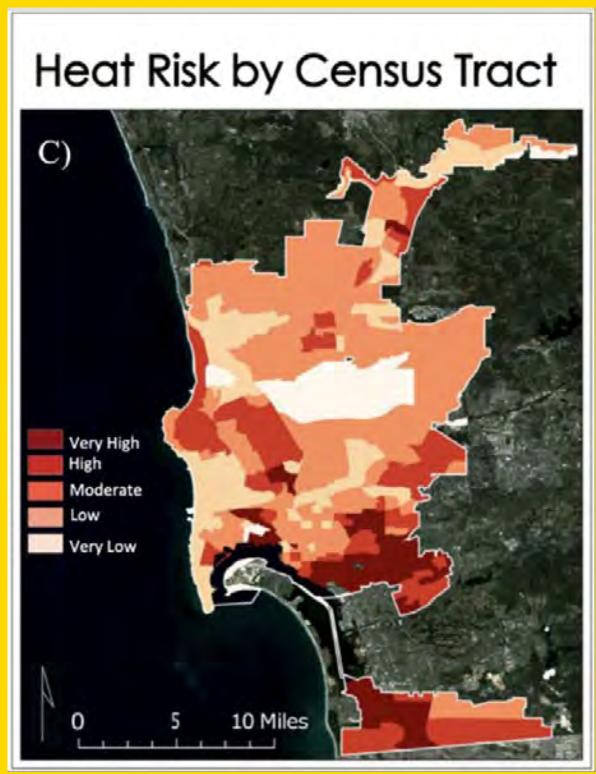
- Support community centered resilience action. Partner with community based organizations to promote preparedness and response actions.
- Develop resilience hubs in coordination with County of San Diego Public Health Department and community-based organizations. Resiliency hubs can provide shelter, food distribution, healthcare, or other services as needed. Consider solar microgrid battery backup implementation.
- Coordinate with the County of San Diego Department of Public Health on Cool Zones program. Provide easily accessible locations, particularly in Communities of Concern. Expand access to Cool Zones, shade corridors and the coast.
- Explore opportunities for neighborhood microgrants to funds community driven projects to enhance community resilience and foster community connections.

CASE STUDY

Urban Heat Vulnerability Index

Like many urban areas, San Diego is facing the effects of climate change, including an increase in frequency of extreme heat events. Rising temperatures from climate change further exacerbate the urban heat island effect. The urban heat island effect is where urban regions are significantly warmer than surrounding undeveloped areas. Urban heat islands are caused by many factors, such as the amount of paved areas or lack of green space. To better address urban heat, the City of San Diego partnered with NASA DEVELOP[1] to create an Urban Heat Vulnerability Index. The NASA DEVELOP team used satellite imagery to look at heat exposure and best available data to consider heat vulnerability factors, such as age or existing health conditions. Heat exposure and vulnerability were combined to assess overall heat risk. The project also analyzed the cooling capacity of areas based on characteristics of the land, such as land cover or tree canopy cover. This Urban Heat Vulnerability Index is an initial implementation of Climate Resilient SD and can be used to prioritize at-risk communities for the implementation of heat reduction or cooling intervention strategies.

[1] This partnership was funded by the Thriving Earth Exchange.



Historic & Tribal Cultural Resources

Goal: Safeguard, preserve and protect historic and tribal cultural resources from the effects of climate change.

San Diego is home to many historic and tribal cultural resources, which can take a wide of variety of forms. These include buildings, structures, objects, districts, archaeological sites and artifacts, traditional cultural properties and tribal cultural resources, historic documents and historical or cultural landscapes. All are important because they tell the story of our region, from when the ancestors of the Kumeyaay and Luiseño peoples first inhabited this area thousands of years ago, up to the present day.

In the City's Climate Change Vulnerability Assessment, historic and tribal cultural resources were found to be highly vulnerable to all climate change hazards except heat. These assets could suffer severe damage, are irreplaceable when destroyed, and their historic and tribal cultural nature requires more thought, consideration, and oversight when implementing protective measures. As the loss or damage of these resources could result in the permanent loss of historic and tribal cultural resources that may be integral to the identity of San Diego, it is critical that we implement policies and adaptation strategies that can help protect them.

Policy HTC-1: Preserve and protect historic and tribal cultural resources against climate change impacts.

Policy HTC-2: Foster partnerships and collaboration opportunities with tribal liaisons and partners.

Policy HTC-3: Honor and share traditional knowledge of land management and cultural significance.

Policy HTC-4: Incorporate climate change considerations into historic and tribal cultural planning and stewardship.

Policy HTC-1: Preserve and protect historic and tribal cultural resources against climate change impacts.

- Practice proactive and robust decision-making for cultural resources. Use modeling and scenario planning to understand likely future impacts of climate change on individual resources; identify intervention options available to mitigate impacts; and implement the intervention measures in a timely manner to maximize preservation efforts.

Policy HTC-2: Foster partnerships and collaboration opportunities with tribal liaisons and partners.

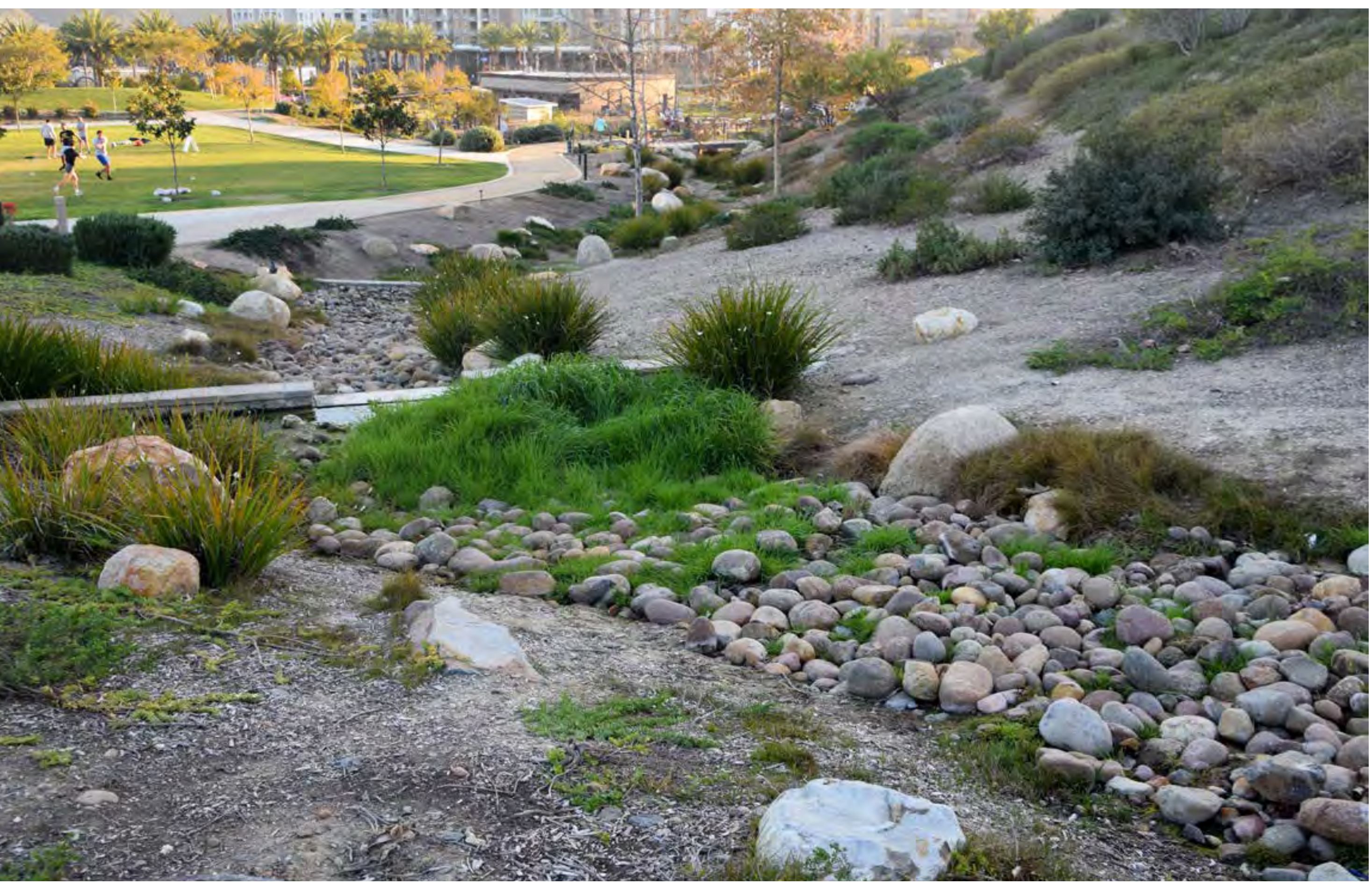
- Coordinate resilience planning with tribal groups and representatives. Foster greater collaboration with tribes and opportunities for partnerships.

Policy HTC-3: Honor and share traditional knowledge of land management and cultural significance.

- Research, write and share climate stories, particularly related to historic and tribal cultural resources.

Policy HTC-4: Incorporate climate change considerations into historic and tribal cultural planning and stewardship.

- Incorporate climate change impacts to historic and tribal cultural resources planning. Develop and implement a cultural resources management plan that aims to reduce stress and minimize exposure of historic, archaeological and tribal cultural resources to climate change impacts.



Thriving Natural Environments

Goal: Support and prioritize thriving natural environments and enhance adaptability.

The City's natural and open spaces provide a multitude of benefits to the region and its residents. Open spaces and parks provide opportunity for active recreation, sports and community gathering. Natural spaces provide critical habitats for endangered species and other wildlife. These spaces also provide valuable resilience benefits and services, such as cleaner air, flood water management and cooler neighborhoods. The protection of our existing natural spaces and expansion of green spaces in our communities will provide social, economic and environmental benefits while better preparing our City for a changing climate.

Policy TNE-1: Protect environmental quality and biodiversity.

Policy TNE-2: Protect and improve the integrity of open space, habitat and parks.

Policy TNE-3: Prioritize the implementation of nature-based climate change solutions wherever feasible.

Policy TNE-4: Prioritize installation of green infrastructure wherever feasible.

Policy TNE-5: Manage the coastline as a social, economic and environmental resource for current and future generations.

Policy TNE-6: Protect and expand the City's urban forest.

A NATURE-BASED SOLUTIONS APPROACH

Nature-based solutions are projects to protect, sustainably manage and restore natural or modified ecosystems, while also addressing societal challenges, improving human well-being and providing biodiversity benefits. A nature-based solutions approach can help the City protect against climate change risks, such as heatwaves, storms and coastal flooding. For example, nature-based projects, such as an expansion of the urban tree canopy, can provide neighborhood cooling on hot days, improve air quality and public health, help absorb rainwater and reduce local flooding, and improve the enjoyability of shared community space. Nature-based solutions also support economic vitality, ensuring that open spaces, beaches, parks and local landmarks are available for recreation and tourism while also encouraging innovation and helping to stimulate the economy with new green jobs. In addition to providing social, economic and environmental benefits, nature-based solutions typically are lower cost over the project lifespan.

While multiple solutions can provide protection against the impact of waves, nature-based solutions like wetland restoration can be more cost effective over time, while also providing education opportunities and critical habitat for many plants and animals.

Success of nature-based solutions depend on healthy ecosystems. A nature-based solutions approach should consider future conditions during planning efforts as many ecosystems may be vulnerable to changing climate conditions. Impacted or damaged ecosystems will have reduced ability to mitigate risk from climate change and to provide the additional benefits associated.

NATURE-BASED SOLUTIONS & OUR COAST

The coast is a natural resource that provides a multitude of benefits to San Diego. A hotspot for biodiversity, the coast is a critical environmental resource. A diverse range of marine life and habitat can be found here, including such iconic species as harbor seals, dolphins, whales and leopard sharks. The coast is also an economic resource, drawing visitors to the region and supporting the tourism industry. Locally, the coast supports many businesses whose customers seek the view of the ocean or the ability to cool off during hot days by the beach. San Diego's beaches and bays also offer incredible recreation value, providing the opportunity to swim, kayak, paddle, surf, boat, camp, jog, play volleyball or simply just relax and enjoy the scenic beauty. The City of San Diego recognizes the great value of the coast, as an economic, environmental and recreational asset for the region. Planning efforts will continue to manage the coastline to ensure that these benefits are available to all San Diegans, now and into the future.

Policy TNE-1: Protect environmental quality and biodiversity.

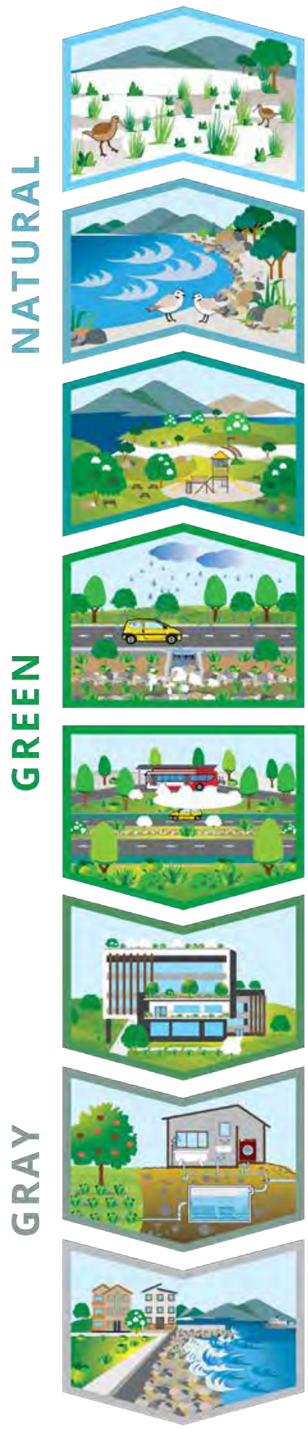
- Develop an ecosystem fire recovery plan to address revegetation and post-fire treatments for open space and community parks if affected by wildfire. The ecosystem fire recovery plan will outline implementation actions for post-fire treatments to protect and improve ecosystem health.
- Develop an action plan to support the completion of the City's Multiple Species Conservation Plan Preserve.

- Continue to implement land management practices that support ecosystem function and healthy watersheds and, in turn, increase the capacity of the system to withstand stress due to climate change.
- Protect, restore and enhance urban canyons. Support habitat restoration of urban canyons, inclusion of environmental education and recreation opportunities and continued preservation.

NATURE-BASED SOLUTIONS

The term “nature-based solutions” encompasses **natural infrastructure**, which includes existing or restored natural landscapes, such as wetlands, forests or open space and **green infrastructure**, which includes a wide range of built or engineered solutions modeled after nature to support purposes such as stormwater management, flooding, urban heat island and climate adaptation.

Gray infrastructure, on the other hand, refers to hard, man-made structures that are engineered for a specific level of service given certain conditions. The following graphic compares several types of nature-based solutions and gray infrastructure that can help address flooding.



Wetlands and floodplains help to mitigate flooding impacts, can improve water quality and provides critical habitat for plants and animals. Coastal wetlands can also help to absorb wave energy and minimize coastal erosion.

Living shorelines stabilize and protect the shoreline using a combination of plants, sand, rock and other natural materials. They can help reduce wave energy, slow erosion and minimize flooding.

Stormwater parks are open space parks or recreational spaces that are designed to flood during extreme precipitation events, which minimizes flooding elsewhere.

Bioswales are vegetated or mulched channels or depressions in the ground that treat and absorb stormwater during a rain event. Bioswales help reduce runoff and minimize peak flows, which can help protect water quality.

Green streets have a range of vegetated or permeable features to integrate stormwater management into the streetscape. They can include features such as rain gardens, vegetated curbs, sidewalk trees or permeable pavements.

Green roofs are partially or completely covered in vegetation and provide a multitude of benefits, from rainwater absorption to reduction of increased heat in highly developed areas, habitat provisioning and air quality improvements.

Underground storage tanks can store water and may also have some capacity to filter water or allow for water infiltration.

Sea walls are hard structures, typically made of concrete, that protect the land behind it from waves up to a certain height, but can result in beach erosion.

Policy TNE-2: Protect and improve the integrity of open space, habitat and parks.

- Prioritize the preservation, restoration and expansion of natural features such as habitat, open space, wetlands, kelp forests, marshes and vegetated buffers to increase resilience of natural systems. Continue to implement and uphold the Multiple Species Conservation Program to preserve network of habitat and open space and to protect biodiversity.

- As identified in the Parks Master Plan, complete a Trails Master Plan. The Trails Master Plan should account for climate change impacts, such as increased erosion due to precipitation or sea level rise.

- Conduct regular brush management in high wildfire risk zones.

- Complete inventory of open space and community park plans to identify needs as related to climate change impacts.

- Update open space and community park plans as needed, including master plans, precise plans, general development plans and natural resource management plans to protect open space and park land against impacts of climate change and to improve natural integrity.

Policy TNE-3: Prioritize the implementation of nature-based climate change solutions wherever feasible.

- Implement nature-based shoreline protection methods to protect areas subject to coastal flooding. Develop a coastal resilience master plan that would identify locations for implementation of nature-based solutions to mitigate coastal flooding and erosion, improve coastal resiliency, protect habitat and increase recreational opportunities for residents and visitors.

In the adaptation strategies survey, 89% of participants preferred soft or nature-based solutions to hard or traditional engineering solutions.

Policy TNE-4: Prioritize installation of green infrastructure wherever feasible.

- Improve stormwater infrastructure resilience.

- Maximize planning and implementation of green infrastructure at watershed scale and site specific.

Policy TNE-5: Manage the coastline as a social, economic and environmental resource for current and future generations.

- Update the City's Local Coastal Program.
- For City-owned properties and leaseholds, consider rolling easements to establish a development boundary that moves inward as sea level rises along the shoreline.
- Update the Coastal Erosion Assessment regularly to identify current conditions of coastline bluffs, beaches, access stairs, ramps, outfalls, seawalls or other related infrastructure.
- Utilize adaptive pathways for coastline planning.

WHAT ARE ADAPTIVE PATHWAYS?

Adaptive pathways is a planning framework that considers the uncertainty of climate change, the change in risk conditions and allows for flexibility in implementation to improve effectiveness and economic efficiency. An adaptive pathways approach identifies thresholds or points in time when decisions or action pathways should be revisited, allowing for adjustments in implementation to be made based off of changing conditions.

Policy TNE-6: Protect and expand the City's urban forest.

- Expand the City's urban tree canopy to meet the City's Climate Action Plan goals.
- Incorporate considerations for a changing climate into urban forestry management and planning. Update the Urban Forestry Program 5 Year Plan with consideration for tree species diversification, salt tolerance, and irrigation needs.

In the adaptation strategies survey, 93% of participants wanted to see more trees and green spaces in their neighborhood. Tree canopy cover, green roofs and cool roofs were the preferred strategies to address heat and improve air quality.

Tourism is San Diego's second largest industry, employing 194,000 people across the county and generating $940 million for the local economy (San Diego Tourism Authority, 2018). Protecting our natural spaces and recreation opportunities that draw people to visit San Diego will help protect San Diego's economy and quality of life for years to come.

Critical City Services

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

The City has completed a Climate Change Vulnerability Assessment in order to understand how climate change-related hazards could affect assets and services owned and managed by the City. The vulnerability assessment found that many critical City assets and services may be vulnerable to climate change related hazards in the future. All of the hazards investigated—wildfire, extreme heat, flooding and drought and sea level rise—pose potential risks to City assets and services.

Damage, disruption or failure of some of these City assets could have major consequences and impede the ability of the City to continue its services and protect public health and safety. Exposure to climate change related hazards could result in consequences such as delays in emergency response; impacts to City facilities; damage to historical, tribal cultural, or archaeological resources; or impacts to protected habitats/species. Implementing potential policies and adaptation strategies that will allow the City to maintain its assets and continue its services with minimal disruption is a key priority.

Policy CCS-1: Protect public health and safety.

Policy CCS-2: Secure and maintain water and wastewater supplies and services.

Policy CCS-3: Improve ability of infrastructure and built systems to withstand climate change shocks and stressors, while maintaining provision of essential services.

Policy CCS-4: Build City capacity to be responsive to future climate change related events and challenges.

Policy CCS-5: Consider cost, effectiveness, lifespan and core benefits for adaptation strategy prioritization and implementation.

Policy CCS-6: Prepare City for upcoming funding opportunities from State, Federal and grant programs to ensure City is competitive to secure funding.

CASE STUDY

City of San Diego Pure Water

The City of San Diego relies on importing 85% of its water supply from the Colorado River and Northern California Bay Delta. Limited control over its water supply increased the City's vulnerability to droughts, climate change, and natural disasters. The Pure Water Program will reduce vulnerability and increase resiliency of the City's water supply by providing almost half of the City's water needs by 2035. The Pure Water Program uses proven technology to clean recycled water to produce high-quality drinking water.

Photo provided by Public Utilities Department. More than 50,000 lab tests have been conducted to ensure the water produced at the Pure Water Demonstration Facility is safe to add to San Diego's drinking water supply. As part of the City's Pure Water outreach program, nearly 19,000 people have toured the one million gallon-per-day Demonstration Facility since it came online in June 2011.

Policy CCS-1: Protect public health and safety.

- Identify critical transportation network elements and create emergency transportation alternatives and detours for vulnerable routes. Prioritize corridors that act as evacuation routes or provide access to critical facilities.
- Develop a flood assistance program.
- Establish levees inspection and maintenance program to ensure the levee system continues to provide an adequate flood protection. Update the Levee System Operation and Maintenance Manual.

Policy CCS-2: Secure and maintain water and wastewater supplies and services.

- Continue to update the Urban Water Management Plan every five years to reexamine future vulnerabilities to the City water supply.
- Continue efforts to diversify the City's water supply sources and reduce dependence on imported water.
- Promote stormwater as a resource concept by implementing capture and reuse technologies where feasible.
- Replace or rehabilitate water and wastewater pipes to maintain a state of good repair, minimize breaks and ensure structural integrity in the face of climate change hazards such as flooding.
- As Water Design Guidelines and Sewer Design Guidelines are updated, consider climate change impacts, such as sea level rise, coastal erosion and changes in precipitation.
- Account for projected changes in precipitation and sea level rise in water and wastewater planning.
- Prepare and implement a facility climate change action plan for Point Loma Wastewater Treatment Plant.
- Continue efforts to increase wastewater diversion to further reduce likelihood of sanitary sewer overflow.
- Conduct detailed site assessments at active, identified vulnerable waste and wastewater facilities and identify climate change hazard risk mitigation options.
- Integrate projected increases in wildfire frequency and intensity into watershed management and planning, dam and

raw water reservoir operations and dam emergency planning, in alignment with City's Climate Action Plan.

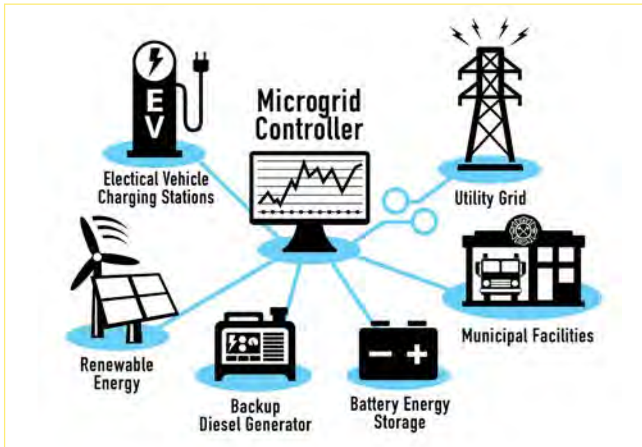
- Promote water conservation through updates to the City irrigation system.

Policy CCS-3: Improve ability of infrastructure and built systems to withstand climate change shocks and stressors, while maintaining provision of essential services.

- Provide cooling systems for City assets and equipment sensitive to overheating.
- Plan for a climate ready transportation network.
- Identify and implement flood protection measures for critical infrastructure.
- Protect mechanical, electrical and other key operational equipment from flooding at critical facilities through facility improvements or adaptive action.
- Conduct site assessments at City facilities and ensure effective management of vegetation, defensible space and hardening of assets as feasible for wildfire preparedness.

Policy CCS-4: Build City capacity to be responsive to future climate change related events and challenges.

- Develop workforce preparedness training opportunities and programs to quickly restore essential City services.
- Build redundancy and/or backup resources available to support critical operations and services during an emergency event.
- Implement a knowledge transfer and training program to ensure that natural hazard response procedures are not lost with staff turnover.
- Create a web map for primary climate change hazard impacts. Update City's geographic information system database as best available science for climate change projections and State guidance is updated.
- Account for high heat days when planning City staff duties to minimize exposure to extreme heat and/or provide necessary protective measures.
- Consider the value of combining renewable generation with battery energy storage systems and/or microgrid installations to increase resiliency in the face of climate change driven energy disruptions, reduce energy costs and support a stable electric grid.



Sustainability Microgrids

Microgrids are standalone power grids that allow a building or set of connected buildings to isolate from the grid and continue to operate during power outages. Renewable microgrids use only renewable energy created and stored onsite to continue to operate during power outages. Smart microgrids allow a building's energy use to dynamically shift to when utility prices are low, resulting in decreased energy operating costs. The City is exploring the use of microgrids to increase the resiliency of its electrical infrastructure, decrease energy costs, and reduce greenhouse gas emissions.

- Implement resilient redesign or identify less intensive land uses for City owned property exposed to flooding.
- Establish a Chief Resilience Officer.
- Identify City buildings appropriate for installation of distributed energy resources like battery energy storage and microgrids to increase City capacity to respond to climate change driven energy disruption and reduce energy costs.
- Explore siting renewable generation projects on City owned land, landfills, lakes and reservoirs.

Policy CCS-5: Consider cost, effectiveness, lifespan, and core benefits for adaptation strategy prioritization and implementation.

- Create City tracking system to monitor the cost of climate change hazard impacts and response.
- Develop a post hazard tracking system to collect post-event cost data for events that are both above and below the national hazard declaration threshold. Track in a shared asset management database for climate change hazard related cost impacts.
- Develop guidance for capital planning, including resilient design standards for City infrastructure upgrades that considers climate change projections. Consider the project’s function, lifespan, location, asset type and core benefits provided by the project. Includes resilient design criteria as prioritization factor for capital improvement projects.

Policy CCS-6: Prepare City for upcoming funding opportunities from State, Federal and grant programs to ensure City is competitive to secure funding.

- Explore proven financing tools and emerging grant opportunities to fund resilience focused projects.
- Integrate climate adaptation, resilience and hazard mitigation into long range planning documents as well as land use planning, capital and budget plans.
- Form a City department climate adaptation working group to coordinate on climate adaptation implementation efforts.

San Vicente Energy Storage Facility

The San Vicente Energy Storage Facility is a pumped energy storage project that will provide up to 500 megawatts of renewable energy upon completion. This join project by the City of San Diego and San Diego County Water Authority received $18 million from the State to fund initial design, environmental review and the federal licensing process.

Photo: SDFish.com.

Implementation Framework

CONTINUED COMMUNITY INVOLVEMENT

Implementation will prioritize strategies that protect areas in the City that have the greatest needs, benefit the most people and address areas or assets most vulnerable to climate change hazards. Continued equitable public engagement throughout plan implementation will ensure that community voices continue to be heard, that implementation meets needs of communities and will support long term implementation success.

LIVING DOCUMENT

Wildfires, heat, flooding and sea level rise are already impacting the City. Early action will enable the City to take a proactive approach to address climate risks and more effectively leverage resources to build prepared and resilient communities. As the City implements *Climate Resilient SD*, continued effort will be needed to monitor the success and outcomes of adaptation strategies as they are implemented.

As the best available science is updated, new technologies emerge and the understanding of implementation outcomes of adaptation strategies grows, the specific prioritization and selection of adaptation strategies may need to be adjusted. To continue to reflect best available science, community need and implementation outcomes, the *Climate Resilient SD* plan should be updated regularly, at least every 5 years.

ADAPTIVE IMPLEMENTATION

Climate Resilient SD is intended to provide a flexible framework for implementation, consisting of goals, policies and adaptation strategies that address climate change impacts to the City's people, natural resources, infrastructure and services, with a focus on building stronger, more equitable and more sustainable communities. The strategies are a combination of policies, plans and implementation actions, in alignment with the City's Climate Action Plan, that provide pathways forward to increase the City's capacity to adjust to and prepare for a changing climate. Flexibility in implementation will enable the City to select strategies that will best mitigate risk and build resilience for communities, the environment and the economy.

FUNDING OPPORTUNITIES

To meet the challenge of climate change and to build a more resilient, more equitable city will require significant funding and investment. The level of investment needed cannot be met by existing funding streams alone. New sources of funding will be needed to meet implementation goals. With significant funding anticipated from Federal, State and other granting agencies, the City must be prepared to successfully compete for and secure available funds.

To best position the City to be eligible, ready and competitive for available funding, the City's funding strategy should include alignment of planning efforts, integration of resilience into capital planning, close coordination between departments and consideration of the staff capacity and resources needed for implementation. Building partnerships with community groups and continuing regional collaboration will accelerate San Diego's transition to a climate ready, resilient city.

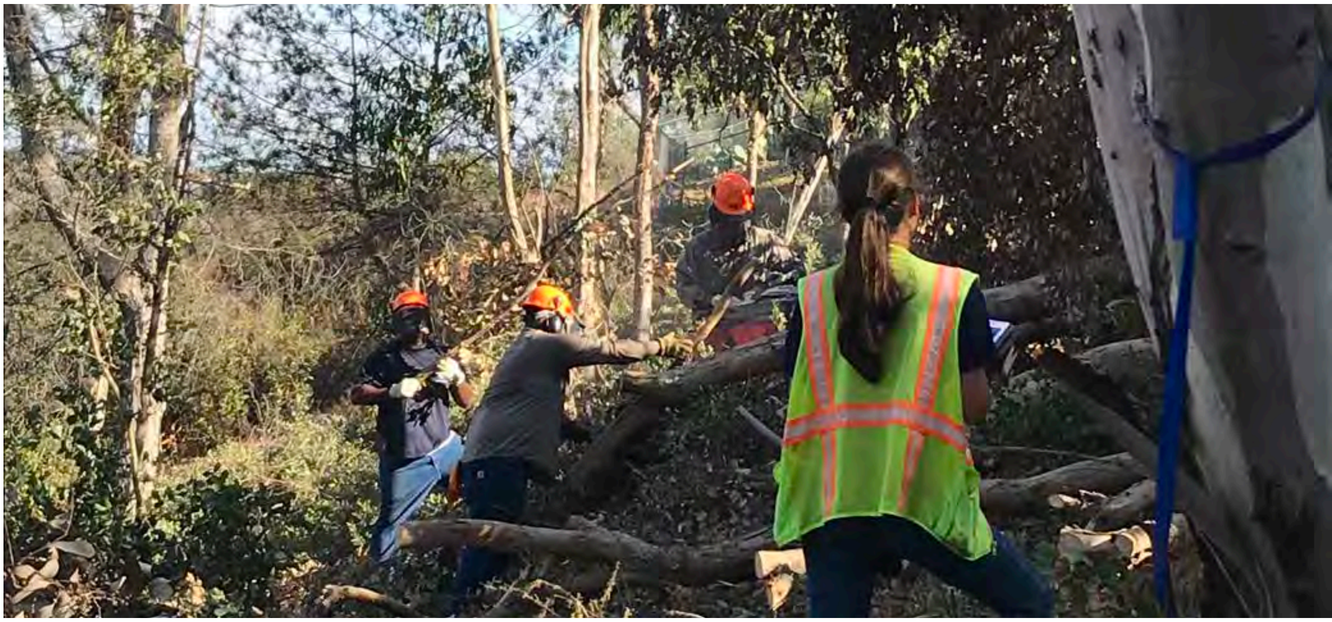
In addition to continual pursuit of new funding opportunities, the following potential grant funding sources should be pursued wherever feasible:

Potential Federal Grants:

- FEMA Hazard Mitigation Program (HMP)
- FEMA Building Resilient Infrastructure and Communities (BRIC)
- FEMA Flood Mitigation Assistance (FMA)
- NOAA Climate Program Office
- EPA Clean Water State Revolving Fund
- EPA Greening America's Communities / Building Blocks for Communities

Potential State Grants:

- Coastal Conservancy Climate Ready Program
- California Climate Investments (CCI) Urban & Community Forestry Grant Program
- Proposition 1: Integrated Regional Water Management (IRWM) Grant Program
- Department of Water Resources Floodplain Management, Protection, and Risk Awareness Grant Program
- Wildlife Conservation Board Habitat Enhancement and Restoration Program



Appendix A

Adaptation and Resilience Strategies

Adaptation and Resilience Strategies

How to Read a Strategy:

1. Climate Hazard

Wildfire

Coastal Hazards: coastal flooding and coastal erosion

Extreme Heat

Flooding and Drought

2. Adaptation Strategy

The strategy is a primary action, policy or program to achieve the goals of Climate Resilient SD.

3. Adaptation Strategy Additional Information

Provides additional information, context and/or action items for the adaptation strategy.

4. Implementation Timeframe

Identifies the timeline for the strategy to be implemented. **Near:** Next 5 years; **Mid:** Next 10 years; **Long:** 10 years +; **Ongoing:** Continuous action.

5. Core Benefits

Identifies additional benefits associated with implementation of the adaptation strategy

City Services: maintain critical services provided by the City, such as maintaining streets, water supply, and Fire-Rescue services.

Public Health and Safety: protect members of the public from the effects of extreme heat, flooding, and other climate hazards.

Historic and Tribal Cultural: protect historic and tribal cultural resources such as historic structures, archaeological sites and artifacts and cultural landscapes against the impacts of climate change.

Recreation, Green Spaces & Tourism: protect the City's recreational spaces, such as parks and beaches, so that residents and visitors alike can continue to enjoy them.

Water Quality & Use: Protect and improve the integrity of our water bodies through stormwater management and promotion of water conservation actions.

Natural Resource Protection and Air Quality Improvement: Protect and improve integrity of the City's natural spaces and resources, providing a multitude of benefits to the City's residents including air quality improvement.

Greenhouse Gas Reductions: Reduce emissions of climate change causing greenhouse gases into the atmosphere.

Economic Continuity: Help the City's economy to continue thriving in the face of climate change impacts.

Social Equity: Protect the City's most vulnerable communities from the effects of climate change.

6. Implementation Cost Estimate

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Identifies an order of magnitude cost estimate for implementation of the adaptation strategy. **Low** is up to $1 million, **Medium** is $1 million to $10 million, **High** is exceeding $10 million.

7. O&M Estimate

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Identifies an order of magnitude cost estimate for ongoing operations and maintenance of the adaptation strategy. **Low** is up to $1 million, **Medium** is $1 million to $10 million, **High** is exceeding $10 million.

1 CLIMATE HAZARDS	2 ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	4 TIMEFRAME	5 CORE BENEFITS	COST CAPITAL / O&M
	Increase investment in a citywide public outreach and education campaign to increase the public awareness of water quality matters. 3 Increase investment in launching a citywide public outreach and education campaign to educate the general public, businesses and stakeholders on stormwater quality issues. The campaign can include development of educational material, increase in multimedia communication efforts to reach broader audiences, expanded stakeholder engagement, partnerships with private and nonprofit groups and expansion of the rebate program to incentivize residents and businesses to install rain barrels, disconnect downspouts and xeriscaping.	**Near to Mid**		\$ 6 \$ 7

Goal: Ensure communities are connected and informed to be best prepared for climate change.

Policy: CI-1: Provide easily accessible education resources and grow community awareness of climate change.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Develop a comprehensive climate adaptation community outreach program. Conduct community outreach through various methods and in multiple languages to share climate change and climate adaptation information and resources with communities. Create a communication strategy and identify City communication resources to be used to notify the public in advance of, during and after an extreme climate change hazard event. Communicate the impact of climate change hazards to the City and potential adjustments in services with and without adaptation action. Tell the story of the effects of climate change by creating interpretive signage, developing a photo series of changes or other communication methods. Encourage individual resiliency action through educational materials. Implement pilot adaptation projects to inspire and create public awareness. Outreach campaigns could include topics such as water conservation, fire safety or bike safety and cycling education. Provide information and guidance for landowners in areas that are potentially prone to climate change hazards.	**Near, Ongoing**		$ / $
	Increase investment in a citywide public outreach and education campaign to increase the public awareness of water quality matters. Increase investment in launching a citywide public outreach and education campaign to educate the general public, businesses and stakeholders on stormwater quality issues. The campaign can include development of educational material, increase in multimedia communication efforts to reach broader audiences, expanded stakeholder engagement, partnerships with private and nonprofit groups and expansion of the rebate program to incentivize residents and businesses to install rain barrels, disconnect downspouts and xeriscaping.	**Near to Mid**		$ / $

Goal: Ensure communities are connected and informed to be best prepared for climate change.

Policy CI-2: Enhance ability of communities to prepare for, respond to, and recover from climate change impacts.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Provide grid resilience services through grid-integrated vehicle programs. Pilot a variety of grid resilience services, such as demand response, emergency back-up, and demand charge reduction, through three modes of electric vehicle integration: Grid-to-Vehicle, Vehicle-to-Building, and Vehicle-to-Grid.	**Near to Mid**		$$ / $
	Develop resilient design guidelines or modify zoning, permitting processes and standards to support smart, sustainable, resilient development and reduce exposure to climate change hazards. Design guidelines should consider future precipitation, sea level rise, wildfire, and heat projections. During design phase, plan for climate change projections for lifespan of development and any beneficial resilience retrofits. Resilient design guidelines should protect public health and safety and prioritize inclusion of nature-based solutions. Resilient design guidelines could include: a) Guidelines for new development or redevelopments. b) Guidelines for building retrofits. c) Guidelines for design of resilient playgrounds and athletic fields that consider use as temporary flood mitigation areas. d) New "climate resilient" zones, such as coastal resiliency zone or heat resiliency zone. Following completion of the resilient design guidelines , the City's Local Coastal Program should be updated accordingly to reflect new policies and regulations.	**Near**		$ $$ $$$ / $
	Hold community trainings for emergency response and preparedness. Community trainings can include in person or online trainings on both personal preparedness and hands on emergency response. Trainings would provide public education opportunity and resources for citizens to learn how to prepare for and respond to events such as wildfires.	**Near, Ongoing**		$ / $
	Expand and amplify wayfinding and public outreach campaigns for wildfire response. Support community preparedness with focused public outreach. Consider needs of those without car access or with additional accessibility requirements. Identify and mark emergency routes in the wildland-urban interface in case of evacuations.	**Near, Ongoing**		$ / $

Goal: Ensure communities are connected and informed to be best prepared for climate change.

Policy CI-3: Strengthen the City's regional partnerships to leverage and expand available resources for climate resilient actions.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Build regional resilience through collaboration with other local, regional or State agencies, as well as community based organizations and non-profits. Continue regional collaboration with San Diego Associations of Government (SANDAG), the County of San Diego, the Port of San Diego and other local or regional agencies. Build relationships with local community based organizations. Continue participation in San Diego Regional Climate Collaborative and Adaptation Planning Working Group. Enhance existing City partnerships with appropriate local agencies, community support groups, and service providers to better mitigate hazards that may increasingly result from severe weather and/or climate change.	**Near, Ongoing**		$ / $
	Coordinate with local transit agencies for resilient public transit systems upgrades. Coordinate with Caltrans, MTS, and SANDAG for innovative designs for public transit systems, such as "Moss Stops", to support use and comfort of public transit system with future climate conditions. As applicable, consider adding resilient design features to Mobility Choices program to support more widespread implementation.	**Near, Ongoing**		$ / $
	Collaborate with climate science experts on local climate change impacts, mitigation and adaptation to inform public policy decisions. Collaborate with local research institutions and universities for research and monitoring projects to inform implementation of Climate Resilient SD. Coordinate with regional and State agencies and climate science experts on best available science and emerging research.	**Near, Ongoing**		$ / $

Goal: Ensure communities are connected and informed to be best prepared for climate change.

Policy CI-4: Collaborate with arts, cultural and creative sector to increase community awareness of and engagement with climate planning.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Explore varied approaches and platforms to engage people in discourse, learning and actions around climate change and the environment. Arts and culture can be an essential tool for the City in generating creative climate action and environmental engagement. Approaches could range from creative content and awareness building to using artistic practices, creative events and public art interventions to support plan implementation.	Mid		$ / $
	Develop a cultural plan that connects arts and culture with City sustainability and resiliency goals. The citywide cultural plan would support sustainability and resiliency objectives and further art and culture infrastructure as an element of community engagement and awareness.	Mid		$ / $

Goal: Plan for and build a resilient and equitable City.

Policy RE-1: Prioritize resilience investments and implementation of strategies in Communities of Concern, as identified in the Climate Equity Index.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Ensure Capital Improvement Program integrates climate resilience and equity considerations into the budgeting and project selection process. Integrate Climate Equity Index, climate change hazard maps and climate projections into capital project planning. Integrate climate resiliency and equity as a prioritization factor. Include climate risks in capital planning and Return on Investment calculations. Consider future Operation and Maintenance and repair costs due to climate change related hazards.	**Near, Ongoing**		$ / $ $$ $$$
	Utilize Climate Equity Fund and other funding sources to direct investments to resilience projects in Communities of Concern. Investments should be directed to communities with the greatest need and where the investment can provide the greatest benefit. Utilize Climate Equity Fund as well as other funding sources, such as State and Federal grants, to build community resilience and address existing inequities in infrastructure and community resources.	**Near, Ongoing**		$$ / $$
	Work with Office of Race and Equity to ensure need and priorities of residents in Communities of Concern are reflected in plan implementation. Collaborate closely with Office of Race and Equity to ensure that people that live in Communities of Concern feel heard and included in implementation.	**Near, Ongoing**		$ / $

Goal: Plan for and build a resilient and equitable City.

Policy RE-2: Foster vibrant, healthy and sustainable communities.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Support expansion and management of active transportation network. Provide safe, accessible active transportation infrastructure. Expand active transportation network, including sidewalks, bike lanes and public transit facilities, to improve connectivity to employment and residential areas. Consider future climate conditions when planning active transportation infrastructure, such as the need for additional trees for air quality improvement and heat mitigation or implementation of bioswales for floodwater retention.	**Near, Ongoing**		$$ / $
	Explore opportunities and programs to increase access to healthy food markets, farmer's markets and other local food networks, particularly for low income residents and families. Work to expand access to healthy food, organic options and ensure affordability. Coordinate and partner with the County of San Diego's Live Well Community Market Program.	**Near to Mid**		$ / $
	Increase access to parks and open space for all San Diegans. Increase overall shaded area at park spaces. Natural shade from trees shall be prioritized over artificial shade structures whenever feasible. Access to parks and open spaces can provide cooling effect for localized areas during extreme heat events and can help improve air quality. Access to green spaces also improves quality of life, physical and mental health and promotes social cohesion.	**Near, Ongoing**		$$ / $$
	Incentivize installation of cool roofs and green roofs. a) Assess cool roof requirements under San Diego Municipal Code Charter 14, Article 5, Division 15. Consider broadening conditions that would require cool roof implementation. b) Assess feasibility of expansion of Eco-roof program from Centre City district to other areas of the City, with strong consideration for Transit Priority Areas, Communities of Concern, and areas of high heat risk.	**Near, Ongoing**		$ / $$
	Utilize the Urban Heat Vulnerability Index to inform implementation of adaptation strategies to address extreme heat events and identify priority areas for cooling interventions. The Urban Heat Vulnerability Index (UHVI) evaluates risk to extreme heat based upon social and health factors as well as exposure based upon land use. Utilize the UHVI to guide implementation of cooling strategies. Prioritize strategies with cooling and air quality benefits.	**Near**		$ / $

Goal: Plan for and build a resilient and equitable City.

Policy RE-3: Prioritize strategies with multiple benefits that increase the adaptive capacity of the City's most vulnerable communities.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Establish a community garden program to convert vacant lots, rooftops or other available space to public community gardens. A public community garden program would support conversion of private or City owned vacant lots to community spaces. Program could include training sessions or courses to provide citizens with skills to empower community leadership for urban green spaces and could include toolkit to guide establishing garden and setting up volunteer network.	Near		\$ / \$
	Develop an urban greening program to promote expanded green spaces in urban areas. The program should facilitate greening of City buildings and encourage private development to include green features through policy development or incentive programs. The urban greening program should consider the following: a) green walls. b) green facades. c) green roofs. d) "moss stops", and other projects that would add green spaces, either vertically or horizontally. The program should include a guidance document that compiles best available research on green walls, facades, roofs or other urban greening tools to provide urban cooling and air quality improvement. The guidance document should provide technical advice on the design, construction and maintenance of these projects.	Mid		\$ / \$ \$\$ \$\$
	Collaborate with the Air Pollution Control District (APCD) to implement the Community Emissions Reduction Plan (CERP) and AB 617. The Community Emissions Reduction Plan (CERP) works to reduce air pollution and improve public health for communities that disproportionately experience exposure to air pollution. The CERP works to reduce air pollution emissions and to lessen community exposure.	Near to Mid		\$ / \$

Goal: Plan for and build a resilient and equitable City.

Policy RE-4: Deepen community partnerships to support greater community involvement in resilience action and plan implementation.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Cultivate leadership and environmental stewardship in San Diego's youth. Consider partnerships with local schools and universities, focused internship programs and leadership opportunities. Build climate and eco-literacy through education and outreach materials.	**Near, Ongoing**		$ / $
	Create principles for meaningful, equitable community engagement. Identify ways to remove barriers to participation. In coordination with the Office of Race and Equity, develop principles for community engagement that meaningfully involve frontline communities and Communities of Concern to guide outreach and engagement efforts during Climate Resilient SD plan implementation.	**Near**		$ / $
	Promote water conservation, water reuse and best management practices in local businesses and industry. Example programs include: Guaranteed Water For Industry: participating businesses use reclaimed water to extent possible in manufacturing, cooling, landscaping, or other operations. Participating businesses also implement best management practices for potable water conservation in their facilities and operation. Participation in program provides businesses assurance of available supply of water and discounted rates for reclaimed water usage.	**Near, Ongoing**		$ / $

Goal: Plan for and build a resilient and equitable City.

Policy RE-5: Ensure vulnerable communities have resources necessary to respond to climate change impacts.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Support community centered resilience action. Partner with community based organizations to promote preparedness and response actions. Develop centralized virtual location for information and resources related to climate change hazard events and response. Work with community based organizations to identify and meet community specific needs.	Near, Ongoing		$ / $
	Develop resilience hubs in coordination with County of San Diego Public Health Department and community-based organizations. Resiliency hubs can provide shelter, food distribution, healthcare, or other services as needed. Consider solar microgrid battery backup implementation Resilience hubs can enhance climate resilience by serving as cooling centers, emergency shelters or providing training on coping with climate change hazards. Coordinate with the County, community partners and Office of Emergency Services.	Mid		$ / $
	Coordinate with the County of San Diego Department of Public Health on Cool Zones program. Provide easily accessible locations, particularly in Communities of Concern. Expand access to Cool Zones, shade corridors, and the coast. Ensure City residents are informed about cooling center locations available during extreme heat events. Designate and add additional cooling centers as needed that are accessible, near vulnerable populations, and/or co-located with other services. Explore development of a Cool Zones App that would help people get information about extreme heat events, locate designated Cool Zones, and identify shade corridors.	Near, Ongoing		$ / $ $$
	Explore opportunities for neighborhood microgrants to funds community driven projects to enhance community resilience and foster community connections. Grants could go towards community garden, community greening, or other community enhancing projects. Microgrant program would be designed to foster connection, develop local leaders, engage citizens, create a greater sense of community and provide resilience benefits.	Mid		$ / $

Goal: Safeguard, preserve and protect historic and tribal cultural resources from the effects of climate change.

Policy HTC-1: Preserve and protect historic and tribal cultural resources against climate change impacts.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Practice proactive and robust decision-making for cultural resources. Use modeling and scenario planning to understand likely future impacts of climate change on individual resources; identify intervention options available to mitigate impacts; and implement the intervention measures in a timely manner to maximize preservation efforts.	Mid		$ / $

Goal: Safeguard, preserve and protect historic and tribal cultural resources from the effects of climate change.

Policy HTC-2: Foster partnerships and collaboration opportunities with tribal liaisons and partners.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Coordinate resiliency planning with tribal groups and representatives. Foster greater collaboration with tribes and opportunities for partnerships.	Near, Ongoing		$ / $

Goal: Safeguard, preserve and protect historic and tribal cultural resources from the effects of climate change.

Policy HTC-3: Honor and share traditional knowledge of land management and cultural significance.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Research, write and share climate stories, particularly related to historic and tribal cultural resources. Document history and heritage of historic and tribal cultural resources. Consider methods for storytelling, such as StoryMaps, interpretive signage or education kiosks. Collaborate with subject matter experts, tribal representatives and local universities for creation and sharing of stories.	Mid		$ / $

Goal: Safeguard, preserve and protect historic and tribal cultural resources from the effects of climate change.

Policy HTC-4: Incorporate climate change consdieration into historic and tribal cultural planning and stewardship.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Incorporate climate change impacts to historic and tribal cultural resources planning. Develop and implement a cultural resources management plan that aims to reduce stress and minimize exposure of historic, archaeological, and tribal cultural resources to climate change impacts. a) Develop a prioritized list of historic and cultural resources to preserve and protect from climate change impacts for current and future generations. Collaborate with subject matter experts, archeological community, tribal representatives and local universities to develop methods for prioritization. Prioritization factors may include, significance of the resource, rarity of the resource, immediacy of the climate change threat, stakeholder input and the feasibility, effectiveness and cost of available interventions. b) Develop a cultural resources management plan that includes a baseline of existing resources condition, identifies necessary active interventions and include a monitoring program to track conditions of cultural resources and identify vital signs for resource impact. c) Evaluate staffing and budgetary needs for ongoing resiliency planning and monitoring of historic and tribal cultural resources. Coordinate across City departments.	**Mid**		$ / $$

Goal: Support and prioritize thriving natural environments and enhance adaptability.

Policy TNE-1: Protect environmental quality and biodiversity.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Develop an ecosystem fire recovery master plan to address revegetation and post-fire treatments for open space and community parks if affected by wildfire. The ecosystem fire recovery master plan will outline implementation actions for post-fire treatments to protect and improve ecosystem health.	**Near to Mid**		$ / N/A
	Develop an action plan to support the completion of the City's Multiple Species Conservation Plan Preserve. The action plan should include, but is not limited to, the following: a) Support acquisition of target habitat types within the Multi-Habitat Planning Area (MHPA) to meet overall conservation goals under the MSCP Implementing Agreement. Strong consideration for habitat types with greater conservation gaps should be given, including but not limited to: freshwater marsh, open water, disturbed wetland and shallow bays. b) Update Habitrak to depict MHPA boundary line adjustments to accurately account for City conservation acreage inside the MHPA. c) Assemble interdepartmental City MHPA acquisitions team to guide and streamline MHPA land acquisition process. d) Create and foster MSCP partnerships.	**Near to Mid**		$ / $
	Continue to implement land management practices that support ecosystem function and healthy watersheds and, in turn, increase the capacity of the system to withstand stress due to climate change. Land management practices include: brush/vegetation management around City raw water storage reservoirs, invasive species or weed removal in watershed, habitat restoration, streambed rehabilitation for riparian protection, implementation of stormwater best management practices and erosion control measures.	**Near, Ongoing**		$ / $
	Protect, restore and enhance urban canyons. Support habitat restoration of urban canyons, inclusion of environmental education and recreation opportunities and continued preservation. Urban canyons provide ecosystem services including biodiversity, water quality improvement, heat mitigation and provision of habitat. They also provide recreational opportunities and opportunity to connect and learn about nature.	**Near, Ongoing**		$$ / $$

Goal: Support and prioritize thriving natural environments and enhance adaptability.

Policy TNE-2: Protect and improve the integrity of open space, habitat and parks.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Prioritize the preservation, restoration and expansion of natural features such as habitat, open space, wetlands, kelp forests, marshes and vegetated buffers to increase resilience of natural systems. Continue to implement and uphold the Multiple Species Conservation Program to preserve network of habitat and open space and to protect biodiversity. Expand open space and protect natural ecosystems in flood hazard areas. Protect integrity of existing wetlands. Consider restoration program to restore degraded habitat and expansion of wetland habitat as feasible.	Near, Ongoing		$$ / $
	As identified in the Parks Master Plan, complete a Trails Master Plan. Trails Master Plan should account for climate change impacts, such as increased erosion due to precipitation or sea level rise. The proposed Trails Master Plan would confirm trail construction standards for new trail construction, identify which trails should remain, identify trails to be restored to natural condition and identify trails that require upgrade projects. Trail maintenance procedures for cliff trails, parks and preserves should consider increases in erosion and flooding due to climate change hazards.	Near, Ongoing		$ / $$
	Conduct regular brush management in high wildfire risk zones. Vegetation and brush management reduces intensity and spread of wildfire. As needed, brush management should include: invasive species removal, vegetation or brush removal, tree maintenance and removal projects, controlled burn programs, creation of defensible space, fuel breaks and open space management.	Near, Ongoing		$ / $
	Complete inventory of open space and community park plans to identify needs as related to climate change impacts. Inventory will include: a) Status of open space and community park planning efforts. b) Identification of updates required to inform habitat protection, species preservation and natural resource protection.	Near		$ / N/A

Goal: Support and prioritize thriving natural environments and enhance adaptability.

Policy TNE-2: Protect and improve the integrity of open space, habitat and parks.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Update open space and community park plans as needed, including master plans, precise plans, general development plans, and natural resource management plans to protect open space and park land against impacts of climate change and to improve natural integrity. Considerations include: a) Shifts in habitat for endangered or protected species. Consideration of habitat expansion or corridor connections to provide adequate range for movement, migration and interaction of species. b) Preservation and restoration of natural features, such as habitat, open space, wetlands, marshes, vegetated buffers and coastal dunes. c) Increased native plantings to improve natural resiliency to climate conditions, such as drought and wildfire, as well as for natural cliff stabilization.	**Near, Ongoing**		$ / N/A

Goal: Support and prioritize thriving natural environments and enhance adaptability.

Policy TNE-3: Prioritize the implementation of nature-based climate change solutions wherever feasible.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Implement nature-based shoreline protection methods to protect areas subject to coastal flooding. Develop a coastal resilience mater plan that would identify locations for implementation of nature-based solutions to mitigate coastal flooding and erosion, improve coastal resiliency, protect habitat, and increase recreational opportunities for residents and visitors. Nature-based shoreline protection could include beach nourishment, living shorelines, dune restoration, native plantings, habitat restoration, waterfront/floodable parks, kelp farms or oyster reefs.	**Near, Ongoing**		$ $$ / $

Goal: Support and prioritize thriving natural environments and enhance adaptability.

Policy TNE-4: Prioritize the implementation of green infrastructure wherever feasible.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Improve stormwater infrastructure resilience. Enhance implementation of the Watershed Asset Management Plan (WAMP) to evaluate stormwater infrastructure vulnerability to flooding and prioritize infrastructure upgrade and replacement based on highest risk. This includes stormwater pump stations, outfalls, pipes, culverts, levees and channels. Actions include: a) Complete condition assessments for assets. b) Develop upgrade and replacement implementation schedule. c) Evaluate/develop resilience design standards. d) Incorporate a holistic approach for flood mitigation planning and modeling by performing watershed master planning.	Near to Mid		$$$ / $
	Maximize planning and implementation of green infrastructure at watershed scale and site specific. Green infrastructure (GI) provides many benefits to our communities and natural environments. The City invests in GI as an effective, multi-benefit and integrated strategy to protect communities from flooding and protect our waterways from pollutants. GI implementation may include: a) Pursue supplemental funding sources to cover capital cost of GI. b) Expand public outreach to increase awareness of GI benefits. c) Partner with non-profit groups on GI implementation. d) Develop GI design standards to improve GI effectiveness. e) Evaluate and advocate for legislation to support GI.	Near to Mid		$$$ / $$

Goal: Support and prioritize thriving natural environments and enhance adaptability.

Policy TNE-5: Manage the coastline as a social, economic and environmental resource for current and future generations.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Update the City's Local Coastal Program. Local Coastal Program update should incorporate consideration for sea level rise, including coastal flooding and erosion, consistent with State guidance documents and with draft policies included in the Draft Local Coastal Program Policies (Appendix D).	**Mid**		$ / $
	For city-owned properties and leaseholds, consider rolling easements to establish a development boundary that moves inward as sea level rises along the shoreline. Establish the easements as needed to allow for natural migration of shoreline and avoid shoreline armoring.	**Long**		$ / $
	Update the Coastal Erosion Assessment regularly to identify current conditions of coastline bluffs, beaches, access stairs, ramps, outfalls, seawalls or other related infrastructure. The Coastal Erosion Assessment should be updated every five years to evaluate the status of coastline erosion or shoreline change. The assessment will help identify priority locations for projects and funding. Based on findings from Coastal Erosion Assessment, identify funding needs for priority projects to protect public health and safety, protect integrity of coastal habitats and protect coastal access.	**Near, Ongoing**		$ / $
	Utilize adaptive pathways for coastline planning. Adaptive pathways are a sequence of adaptation strategies over time that consider uncertainty and future risk. An adaptive pathways approach should include completion of an economic analysis to evaluate efficiency and effectiveness of adaptation strategies over time. Adaptive pathways should consider: a) Prioritization of nature-based solutions and natural shoreline protection methods to protect areas subject to coastal flooding. b) Consideration of resilience or relocation options for areas highly vulnerable to coastal erosion and/or coastal flooding. c) Consideration of less intensive uses for City assets, such as transition from vehicle based facilities to bike based facilities.	**Mid**		$ / $$$

Goal: Support and prioritize thriving natural environments and enhance adaptability.

Policy TNE-6: Protect and expand the City's urban forest.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Expand the City's urban tree canopy to meet the City's Climate Action Plan goals. Explore innovative funding opportunities to support the expansion and maintenance of the urban tree canopy. Explore options to support tree planting, such as a streamlined process for street trees, or an expanded free tree program.	**Near, Ongoing**		$ / $$
	Incorporate considerations for a changing climate into urban forestry management and planning. Update the Urban Forestry Program 5 Year Plan with consideration for tree species diversification, salt tolerance and irrigation needs. The Urban Forestry Program 5 Year Plan should consider: a) Diversification of tree species, including diversifying tree species that are adapted to higher temperatures and diversifying tree species for those that require less water. b) Planting trees tolerant of future climate conditions, such as salt tolerant trees near the coast. c) Consider future irrigation needs for trees. d) Updated guidance for Street Trees Program.	**Near**		$ / **N/A**

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

Policy CCS-1: Protect public health and safety.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Identify critical transportation network elements and create emergency transportation alternatives and detours for vulnerable routes. Prioritize corridors that act as evacuation routes or provide access to critical facilities. Develop emergency evacuation plans that account for the increasing geographic risk of extreme weather events and that specifically addressing the needs of vulnerable populations. Evacuation plans should by ADA accessible and include all modes of transportation. Evacuation plans should also include route planning, notification testing, potential need for emergency sheltering, and access, egress and road maintenance.	Near to Mid		$ / $
	Develop flood assistance program. Program could include technical advice or materials, such as sandbags and plastic sheeting. Provide flood protection information and resources to community residents and businesses in advance of an event and ensure that vulnerable populations have access to these resources at low or no cost.	Mid		$ / $
	Establish levees inspection and maintenance program to ensure the levee system continues to provide an adequate flood protection. Update the Levee System Operation and Maintenance Manual. Establish levees inspection and maintenance program to ensure the levee system continues to provide an adequate flood protection. a) Conduct inspections and address maintenance deficiencies. b) Update the Levee system Operation and Maintenance Manual. c) Enforce floodplain regulations to protect structures from flooding.	Mid		$$$ / $$

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

Policy CCS-2: Secure and maintain water and wastewater supplies and services.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Continue to update the Urban Water Management Plan every five years to reexamine future vulnerabilities to the City water supply. The Urban Water Management Plan (UWMP) describes the water service area, water demands and supplies, water conservation activities and assesses the reliability of water sources over a 20-year planning time frame. The City's UWMP plan is for 2020-2025, with a planning horizon of 2045. It includes a new water reliability analysis that shows the value of efforts to diversify the City's water supply sources under scenarios considering drought, climate change and seismic events.	Near, Ongoing		$ / $
	Continue efforts to diversify the City's water supply sources and reduce dependence on imported water. Further reduce City reliance on other water sources and increase resiliency of City's water sources. Pure Water Phase I will treat recycled water to produce 30 million gallons of purified water per day. Phase II will further reduce City dependence on imported water sources.	Near, Ongoing		$$$ / $$
	Promote stormwater as a resource concept by implementing capture and reuse technologies where feasible. Increase opportunities for stormwater capture and reuse by evaluating different harvesting methodologies to determine viable options. a) Complete a stormwater harvesting assessment study. b) Develop implementation strategies for viable stormwater capture and reuse options.	Near to Mid		$$ / $$
	Replace or rehabilitate water and wastewater pipes to maintain a state of good repair, minimize breaks and ensure structural integrity in the face of climate change hazards such as flooding.	Long		$$ / $
	As Water Design Guidelines and Sewer Design Guidelines are updated, consider climate change impacts, such as sea level rise, coastal erosion and changes in precipitation.	Mid		$$$ / $
	Account for projected changes in precipitation and sea level rise in water and wastewater planning. The following plans should be considered for update: PUD Water Facilities Master Plan, Integrated Master Plan, and the Forecast Informed Reservoir Operations.	Near to Mid		$ / $

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

Policy CCS-2: Secure and maintain water and wastewater supplies and services.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Prepare and implement a facility climate change action plan for Point Loma Wastewater Treatment Plant. Point Loma Wastewater Treatment Plant Climate Change Action Plan should include the following: a) Identifies impacts based on best available science for climate change projections, b) Identifies steps taken or planned action to address greenhouse gas emissions, c) Identifies steps taken or planned actions to address climate change relate impacts related to sea level rise, changes in precipitation, climate related changes to wastewater flows and climate related changes to influent characteristics. Additional actions could include a site specific study to address potential sea level rise, storm surge and coastal erosion effects at Metro System collection and treatment facilities.	Near		\$ / \$
	Continue efforts to increase wastewater diversion to further reduce likelihood of sanitary sewer overflow. Climate change may result in increased sewer system infiltration and inflow due to increased precipitation intensity and coastal flooding. Additional wastewater diversion increases adaptative capacity of system given uncertainty in the degree to which climate change will influence future infiltration and inflow.	Neat to Mid		\$\$\$ / \$\$\$
	Conduct detailed site assessments at active, identified vulnerable waste and wastewater facilities and identify climate change hazard risk mitigation options. Site specific evaluations will refine the findings of the citywide Climate Change Vulnerability Assessment to account for site specific and facility specific factors. Site assessments will consider the asset's physical characteristics; interdependencies; exposure, sensitivity and adaptive capacity to relevant hazards; overall vulnerability; potential adaptation strategies; and feasibility of implementation options.	Mid to Long		\$ / \$
	Integrate projected increases in wildfire frequency and intensity into watershed management and planning, dam and raw water reservoir operations and dam emergency planning, in alignment with the City's Climate Action Plan.	Mid		\$ / \$
	Promote water conservation through updates to City irrigation system. Updates to irrigation systems can conserve water and save energy. Water management increases irrigation precision to avoid runoff or excess saturation of soil.	Mid		\$\$ / \$

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

Policy CCS-3: Improve ability of infrastructure and built systems to withstand climate change shocks and stressors, while maintaining provision of essential services.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Provide cooling systems for City assets and equipment sensitive to overheating. Complete a review of current equipment and specifications, such as electronics, vehicles and generators, to determine their ability to operate in high heat conditions. Secure cooling systems as necessary to maintain City operations.	Mid		$$ / $
	Plan for a climate ready transportation network. Consider alternative surfaces and cool pavement surfaces when resurfacing roads, critical intersections, multi-use paths and city parking lots. Use alternative pavement surfaces, such as concrete, at critical locations like intersections or bus stops to reduce rutting and cracking due to excess pressure on hot days. Consider other materials that can prevent or reduce buckling of roadways or bridges due to high temperatures. Use light-colored asphalt pavement and consider high-reflectivity hardscape to reduce heat absorption and reflect radiation. Protect road shoulders, embankments and pedestrian and bicycle facilities against erosion. Utilize erosion control treatments including grading, seeding or revegetation, mulch, engineered riprap, hybrid dune and cobble. Consider raising of roadways to manage current and future extreme weather events, where needed to ensure public safety.	Near, Ongoing		$$$ / $$
	Identify and implement flood protection measures for critical infrastructure. Flood protection measures could include: elevating assets above a defined flood level, waterproofing equipment, installing back-up power, placement of sandbags installing flood wall or removable flood barriers, deployable assets and/or waterproofing buildings.	Mid		$$ / $$
	Protect mechanical, electrical and other key operational equipment from flooding at critical facilities through facility improvements or adaptive action. Protection of key operational equipment could include elevation of sensitive equipment above anticipate flood levels, design of structures to withstand exposure to flood water or retrofits to protect against flood conditions.	Near, Ongoing		$$ / $
	Conduct site assessments at City facilities and ensure effective management of vegetation, defensible space and hardening of assets as feasible for wildfire preparedness. Conduct site assessments for critical City facilities within very high fire hazard zone. Site assessments examine vulnerability of site and develops specific adaptation actions to reduce wildfire risk.	Mid		$ $$ / $$

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

Policy CCS-4: Build City capacity to be responsive to future climate change related events and challenges.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Develop workforce preparedness training opportunities and programs to quickly restore essential City services. Review department-level emergency response and management plans, such as Continuity of Operations Plans, to determine if emergency response and recovery strategies account for climate hazards. Incorporate climate hazards into emergency management plans, if necessary, and provide disaster preparedness training to City employees.	**Near, Ongoing**		\$ / \$
	Build redundancy and/or backup resources available to support critical operations and services during an emergency event. a) Maintain list of critical facilities and critical load required for emergency operations. b) Provide critical facilities with diverse sources of energy in case primary source of power is disrupted. c) Support shift toward renewable energy sources of backup power. d) Develop redundant, back-up communication systems between departments to reduce reliance on cell phones in emergencies. e) Secure backup resources, such as backup vehicles, fuel supply, debris removal equipment, rescue equipment, and temporary flood barriers as necessary.	**Near, Ongoing**		\$\$ / \$
	Implement a knowledge transfer and training program to ensure that natural hazard response procedures are not lost with staff turnover. Document existing and future natural hazard response protocols. Hold annual trainings in response departments.	**Near, Ongoing**		\$ / \$
	Create web map for primary climate change hazard. Update City's geographic information system database as best available science for climate change projections and State guidance is updated. Layers to be included and updated regularly, include but are not limited to: a) Federal Emergency Management Agency floodplain layers. b) New Ocean Protection Council or California Coastal Commission guidance on sea level rise or new Coastal Storm Modeling System (CoSMoS). c) New California Environmental Protection Agency Urban Heat Island Index. d) Fire Hazard Severity maps.	**Near, Ongoing**		\$ / \$

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

Policy CCS-4: Build City capacity to be responsive to future climate change related events and challenges.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Account for high heat days when planning City staff duties to minimize exposure to extreme heat and/or provide necessary protective measures. Comply with the Illness and Injury Prevention Plan. Ensure that staff have adequate cooling breaks, sun protection and hydration. Provide heat protective measures for City staff who may be exposed to extreme heat during workdays.	Near, Ongoing		$ / $
	Consider the value of combining renewable generation with battery energy storage systems and/or microgrid installations to increase resiliency in the face of climate change driven energy disruptions, reduce energy costs and support a stable electric grid. Assess implementation of microgrids and battery storage systems to provide backup power for critical city operations and communities. Power microgrids and battery storage with renewable energy sources. Utilize on site energy sources as feasible. Consider implementation of Grid Interactive Efficient Buildings to support implementation and connection of microgrids, provide greater flexibility in energy use and demand response and improve energy efficiency.	Near to Mid		$$ / $$
	Implement resilient redesign or identify less intensive land uses for City owned property exposed to flooding. Resilient redesign could include conversion of leaseholds into riparian buffers or flood mitigation areas to restore natural areas and mitigate flooding. As leases expire, determine most beneficial use of land based on climate change projections.	Long		$$ / $
	Establish a Chief Resilience Officer. The Chief Resilience Officer would lead implementation of Climate Resilient SD. Role responsibilities may include coordination of adaptation strategy implementation, tracking progress across City departments, participating in regional efforts for adaptation planning and implementation and continuing community and stakeholder engagement related to plan implementation.	Near to Mid		$ / $
	Identify City buildings appropriate for installation of distributed energy resources like battery energy storage and microgrids to increase City capacity to respond to climate change driven energy disruption and reduce energy costs. Consider size of microgrid required to support critical load during emergency. Improve energy efficiency of City buildings to reduce overall energy demand and required battery storage capacity. Develop emergency operations energy profiles for critical operations facilities that consider energy needs during times of emergency response.	Near to Mid		$ $$ / $ $$
	Explore siting renewable generation projects on City owned land, landfills, lakes and reservoirs.	Mid		$ $$ / $

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

Policy CCS-5: Consider cost, effectiveness, lifespan, and core benefits for adaptation strategy prioritization and implementation.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Create a City tracking system to monitor the cost of climate change hazard impacts and response. Internal system to track City expenditures related to climate change impacts and response. System would capture smaller events that are not currently tracked by Initial Damage Estimate reports. The tracking system would facilitate reporting on actions taken as well as inform future action when larger capital projects may be required.	**Mid**		$ / $
	Develop post hazard tracking system to collect post-event cost data for events that are both above and below the national hazard declaration threshold. Track in a shared asset management database for climate change hazard related cost impacts. a) Establish a digital reporting system for City employees to record and track disaster response and recovery. b) Recommended metrics for tracking impacts and costs of extreme weather and climate change: frequency of extreme weather events; extent and cause of weather-related damage or infrastructure closures; resultant community impact; maintenance and repair costs; costs of materials/staff time; and frequency of emergency fund requisition.	**Near, Ongoing**		$ / $
	Develop guidance for capital planning, including resilient design standards for City infrastructure upgrades that considers climate change projections. Consider the project's function, lifespan, location, asset type and core benefits provided by the project. Includes resilient design criteria as prioritization factor for capital improvement projects.	**Near**		$$ / $

Goal: Maintain and ensure minimal disruption to all critical City services in the face of climate change hazards.

Policy CCS-6: Prepare City for upcoming funding opportunities from State, Federal and grant programs to ensure City is competitive to secure funding.

CLIMATE HAZARDS	ADAPTATION STRATEGY AND ADDITIONAL INFORMATION	TIMEFRAME	CORE BENEFITS	COST CAPITAL / O&M
	Explore proven financing tools and emerging grant opportunities to fund resilience focused projects. Create a climate resilience specific fund for capital improvement projects. Consider green bonds or resilience focused bonds. Explore policies and funding mechanisms to maintain existing trees and plant and maintain new trees. Coordinate resiliency planning to best position the City to be competitive for State and Federal grant opportunities. Explore other financing tools, such as energy savings performance contracts.	Near, Ongoing		\$ / \$
	Integrate climate adaptation, resilience and hazard mitigation into long range planning documents as well as land use planning, capital and budget plans. Long range planning documents could include, but are not limited to: General Plan, Community Plans, Mobility Action Plan, Climate Action Plan, Integrated Regional Water Management Plan, Watershed Master Plans and Chief Financial Officer 5-year forecast.	Near to Mid		\$ / \$
	Form a City department climate adaptation working group to coordinate on climate adaptation implementation efforts. Effective implementation will require strong coordination between City departments. Establish a climate adaptation point person for each department to lead that Department's implementation actions and supporting actions for applicable adaptation strategies.	Near, Ongoing		\$ / \$

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Appendix B

Climate Change Hazard Vulnerability Assessment

The City of SAN DIEGO

Climate Change Vulnerability Assessment

February 2020

Prepared for the City of San Diego by ICF

This report was prepared with support from a California Coastal Commission LCP Local Assistance Grant and a Caltrans Adaptation Planning Grant.

ICF

Executive Summary

Sea level rise, wildfires, flooding, extreme heat, and other climate change related hazards pose important risks to the City of San Diego. In order to begin preparing for these risks, the City must first understand how climate change could affect assets[1] and services owned or managed by the City. Climate change also poses risks to privately held land within the City.

The City therefore completed a Climate Change Vulnerability Assessment, which assessed the vulnerability of City asset types to climate change hazards This report details those findings, which are summarized in the Key Findings at a Glance box, at right.

About the Vulnerability Assessment

In its 2015 Climate Action Plan (CAP), the City committed to develop a standalone climate adaptation plan to identify vulnerabilities, take early action, integrate adaptation into other CAP efforts, capitalize on co-benefits, and increase local resilience. Completing a vulnerability assessment was the first key step in developing the climate adaptation plan.

The vulnerability assessment was completed in two phases:

- Phase 1, the results of which are presented in this report, included a high-level vulnerability assessment of the City's selected critical asset types. Phase 1 also assessed the consequences of climate change hazards for each asset type;
- Phase 2 involved developing more detailed risk profiles for selected assets from identified vulnerable asset types in Phase 1.

Key Findings at a Glance

Many critical City assets and services may be vulnerable to climate change related hazards going out into the future.

The most vulnerable asset types include:

- **Public safety**: lifeguard stations;
- **Water:** water pipes, wastewater pipes, water pump stations, wastewater pump stations;
- **Transportation and storm water**: bridges, major arterials, drain pump stations, outfalls;
- **Open space and environment**: conservation areas/open space/source water land, community parks;
- **Additional assets**: recreation centers, historical, tribal cultural, and archaeological resources.

Consequences

Damage, disruption, or failure of some of these City assets could have major consequences and impede the ability of the City to continue its services and protect public health and safety. Exposure to climate change related hazards could result in consequences such as delays in emergency response, impacts to City facilities, damage to historical, tribal cultural, or archaeological resources; or impacts on protected habitats/species.

Based on the number of asset types that are vulnerable, wildfire is the primary climate-related hazard for San Diego, followed by sea level rise. However, **all the hazards investigated** (wildfire, sea level rise, extreme heat events, and changes in precipitation) **pose potential risks** to City assets and services.

[1] "Assets" in this context refers to infrastructure, buildings, and other built, natural, and cultural assets owned by the City of San Diego. This vulnerability assessment also considers the exposure of state-owned assets and privately-owned land within the City, such as commercial space, offices, and agricultural land.

The Phase 1 assessment focused on four climate change hazards that are especially important for San Diego:

- **Changes in the frequency and severity of wildfire**. Climate change is projected to increase the key drivers of wildfire (high temperatures, dry conditions, and flammable vegetation) in southwestern California, leading to an increase in fire risk.
- **Sea level rise and related coastal hazards**. Sea level in San Diego is expected to rise five to fourteen times faster over the course of this century than it did in the previous century, leading to risks of increased flooding and coastal erosion.
- **Changes in precipitation**, including heavy rain events and drought. Climate models suggest little change in the total amount of annual precipitation over the course of this century but project more variability in rainfall from year to year and more intense transitions between droughts and deluges.
- **Extreme heat events**. By mid-century, heat waves could be occurring in San Diego three to five times more frequently than in the past.

For each of these hazards, the City selected specific scenarios to be considered in the vulnerability assessment based on the best available climate science. The selected scenarios and corresponding sources are:

- Sea level rise projections for the years 2030, 2050, and 2100 based on the November 2018 update to the California Coastal Commission's (CCC) *Sea Level Rise Policy Guidance* and corresponding U.S. Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS) spatial data;
- Best available localized modeling from CoSMoS for coastal erosion in the area, covering shoreline and cliff retreat under a Medium-High Risk Aversion Scenario of sea level rise by 2100 and various options for coastal armoring or retreat;[2]
- Extreme precipitation scenarios based on the 100-year floodplain and 500-year floodplain

Figure 1. FEMA 100- and 500-year floodplains in the City of San Diego. Floodplain data obtained from FEMA. These reflect 2012 FIRMs for all of the City except South Bay, for which the FIRM was last updated in 2016. Map created: 2019.

[2] The CCC's Medium-High Risk Aversion Scenario indicates a 0.5% probability that sea level rise meets or exceeds a certain height. For 2100, this is 7.0 feet in San Diego. The closest CoSMoS increment for this projection is 2 meters (6.6 feet).

from the Federal Emergency Management Agency (FEMA) Flood Rate Insurance Maps (FIRMs);
- Urban heat island index data from the California Environmental Protection Agency (CalEPA); and
- The City of San Diego's fire hazard and native vegetation zones.

The assessment evaluated the vulnerability of *critical* asset types, which were identified through consultation with City staff based on the following criteria:

- If the asset type/resource (or its function) is necessary for continuity of important City operations;
- If the asset type/resource (or its function) is a key driver in the City's economy;
- If loss of the asset type/resource would present equity concerns;
- If the asset type/resource is critical to safeguarding biological diversity and other environmental priorities.

Evaluating vulnerability entailed assessing the *exposure* of each asset type to each type of climate change hazard, then analyzing the *sensitivity* and *adaptive capacity* of each asset type.[3] The City combined the scores for these three components to determine a vulnerability score for each type of asset for each hazard. Scores for *exposure* indicate the likelihood of the asset types experiencing the climate hazard in question, given the best available science for the predicted spatial extent of the hazard and the location of the assets (Table 1). Scores for *sensitivity* indicate the degree to which a climate hazard might affect an asset type, taking a conservative approach by considering the highest assumed sensitivity within each asset type (Table 2). Scores for *adaptive capacity* indicate the ability of an asset type to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences (Table 3).

Table 1. Rubric for Scoring Exposure of Critical Asset Types to Climate Hazards[4]

	Coastal Erosion	Coastal Flooding[5]	Precipitation	Heat	Wildfire
High	Within the zone eroded under the "Shoreline hold, continued nourish" CoSMoS beach erosion scenario with 2 m sea	Within the zone inundated by the 0.25 m CoSMoS sea level rise scenario (2030)	Within the zone flooded by the FEMA 100-year floodplain	Within the zones with heat score of UHI[6] 80 to 100+	Within the native vegetation zone or its 100-ft buffer

[3] *Exposure* refers to the presence of assets in places that could be affected by climate change hazards (Bedsworth, 2018) citing (IPCC, 2012). *Sensitivity* refers to the degree to which assets are affected by climate change hazards (California Coastal Commission, 2018). *Adaptive capacity* refers to the ability of an asset to cope with the consequences of climate change hazards (California Coastal Commission, 2018) citing (Willows, 2003). Exposure, sensitivity, and adaptive capacity are widely used indicators of vulnerability.
[4] See the Vulnerability Assessment Methodology in the main report for definition of terms in this table.
[5] Coastal flooding refers to both daily flooding and the 100-year storm, given the various sea level rise scenarios.
[6] The urban heat island (UHI) index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree Celsius over an eight-hour period would equal eight

	level rise				
Medium	Within the zone eroded under either the "Cliff let it go" cliff erosion *or* "Shoreline no hold, no nourish" beach erosion scenarios with 2 m sea level rise	Within the zone inundated by the 0.5 to 0.75 m CoSMoS sea level rise scenario (2050)	Within the zone flooded FEMA 500-year floodplain	Within the zones with heat score of UHI 40 to 80	Within the 300-ft buffer of native vegetation
Low	N/A (no low score for erosion)	Within the zone inundated by the 1.0 to 2.0 m CoSMoS sea level rise scenario (2100)	N/A (no low score for precipitation)	Within the zones with heat score of UHI 0 to 40	Within the fire hazard zone outside of brush management zone

Table 2. Rubric for Scoring Sensitivity of Critical Asset Types to Climate Hazards

Score	Rationale
High	If exposed, the asset type becomes damaged beyond repair or destroyed and cannot resume normal function until replaced.
Medium	If exposed, the asset type is damaged such that repairs are necessary before it can resume full functionality.
Low	If exposed, the asset type suffers minor damage but can maintain functionality or is not damaged at all.

Table 3. Rubric for Scoring Adaptive Capacity of Critical Asset Types to Climate Hazards

Score	Rationale
High	The asset can easily be protected from climate impacts (e.g., there are already protective measures in place that adequately prevent impacts; assets can be moved during an event; there are backups available).
Medium	The asset can be protected with some effort (e.g., there are potential protective measures, but they are not yet in place; the asset needs to be retrofitted or upgraded to withstand impacts; backups need to be acquired from other jurisdictions during an event).
Low	The assets cannot be protected (e.g., they are located within an exposed area and cannot be easily moved; there is no level of protection that can fully prevent damage; they are made of sensitive materials and cannot be upgraded; there are no backups available).

The City identified potential consequences that could result from damage, disruption, or failure of critical assets, including impacts on City services; human health; social equity; historical, tribal cultural, and archaeological resources; and natural resources and the environment.

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degree-hours, as would an increase of two degrees Celsius over a four-hour period. Higher scores denote hotter areas.

In addition to these critical City assets, the assessment also considered the exposure of certain non-City asset types to provide a more holistic view of the City overall. Specifically, state highways and freeways are included in the vulnerability assessment to provide a more comprehensive view of the transportation network serving the City. Vulnerability scores were not calculated for these assets, as the City does not have full insight into the sensitivities and adaptive capacities of assets it does not manage.

The City selected and engaged a Stakeholder Advisory Group (SAG) at key points in the vulnerability assessment process. The SAG included representatives from City departments, State government, Federal government, local nonprofits and environmental agencies, community-based organizations, transportation agencies, an energy utility, universities, and other key organizations.

The findings of both Phase 1 and Phase 2 will inform the risk reduction and adaptation strategies developed in the *Climate Resilient SD* Plan.

Findings of the Phase 1 Assessment

Table 4 below presents qualitative (low, medium, and high) vulnerability scores for the City's selected critical asset types to each of the climate change hazards under the scenarios considered in the assessment. Sea level rise hazards are split into coastal flooding and coastal erosion categories, since they represent different types of risks. These vulnerability scores assume no action by the City or implementation of climate adaptation and resilience strategies. Also, the vulnerability scores are based on current best scientific projections of the climate change hazards; there is still uncertainty as to the rate of future global emissions, which will vary based on factors including global population growth, political motivation, and technological changes.

The following critical asset types were determined to be the most vulnerable to climate change hazards based on the combined assessment of exposure, sensitivity, and adaptive capacity:

- **Public safety:** lifeguard stations;
- **Water:** water pipes, wastewater pipes, water pump stations, wastewater pump stations;
- **Transportation and storm water:** bridges, major arterials, drain pump stations, outfalls;
- **Open space and environment:** conservation areas/open space/source water land, community parks, beaches;
- **Additional assets:** recreation centers; historical, tribal cultural, and archaeological resources.

The primary climate change hazard, based on the number of types of assets found to be vulnerable, was wildfire. Twenty-five (out of thirty-one total) asset types were found to have either medium or high vulnerability to wildfire. This is due to an overall high sensitivity to fire, which has the potential to destroy assets in all sectors.

Pale green shading in the table below (and elsewhere throughout the report) indicates asset types that may warrant further study and/or the development of adaptation strategies based on their vulnerability scores. All high vulnerability scores and some of the medium vulnerability scores are shaded green. The shaded medium overall vulnerability scores are those that are comprised of one high scoring component (i.e., exposure, sensitivity, or adaptive capacity) and one medium score (the equivalent of a medium-high score). In practical terms, this approach helps prioritize assets that are on the border between a high and medium, and thus are worthy of further study.

Table 4. Vulnerabilities of all Critical Asset Types to Climate Change Hazards[7]

Sector	Critical Asset	Coastal Flooding: Sea Level Rise (SLR)[8]	Coastal Flooding: Storm Surge with SLR[9]	Coastal Erosion	Precipitation-Based Flooding	Extreme Heat	Wildfire
Public Safety Assets	Fire Stations	N/A	Low	N/A	Low	Low	Medium
	Lifeguard Stations	Medium	Medium	High	Medium	Low	Medium
	Fire Logistics and Dispatch	N/A	N/A	N/A	N/A	Low	N/A
	Maintenance Facilities	N/A	N/A	N/A	Medium	Low	Medium
	Police Stations	N/A	N/A	N/A	N/A	Low	High
	Police Patrol and Specialty Vehicles	N/A	N/A	N/A	Low	Low	Medium
	Other Public Safety	Medium	Medium	N/A	N/A	Low	Medium
Water Assets	Dams	N/A	N/A	N/A	High	Low	Medium
	Water Pipes	Medium	Medium	High	Medium	N/A	N/A
	Wastewater Pipes	Medium	Medium	High	Medium	N/A	N/A
	Water Pump Stations	N/A	N/A	N/A	Medium	Medium	High
	Wastewater Pump Stations	Low	Medium	High	High	Low	N/A
	Distribution Reservoirs	N/A	N/A	N/A	N/A	Medium	Medium
	Water Treatment Plants	N/A	N/A	N/A	N/A	Low	Medium
	Wastewater Treatment Plants	Low	Low	N/A	N/A	Medium	Medium
Transportation and Storm	Airports	N/A	N/A	N/A	Low	Medium	High
	Bridges	High	Medium	High	Medium	Medium	High
	Major Arterials	High	Medium	Medium	Medium	Medium	High
	Drain Pump Stations	High	High	N/A	High	Low	High

[7] Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.
[8] Sea Level Rise (SLR) represents the area that is projected to experience daily flooding at average high tide under each sea level rise scenario.
[9] Storm surge with SLR represents the area that is projected to experience flooding due to the 100-year (1 percent annual chance) storm under each sea level rise scenario.

Sector	Critical Asset	Coastal Flooding: Sea Level Rise (SLR)[8]	Coastal Flooding: Storm Surge with SLR[9]	Coastal Erosion	Precipitation-Based Flooding	Extreme Heat	Wildfire
	Outfalls	High	High	High	High	Medium	Medium
	Levees	Low	Low	N/A	Medium	Low	Medium
Open Space and Environment Assets	Conservation Areas/Open Space/Source Water Land	High	High	High	High	High	High
	Community Parks	High	Medium	High	Medium	Medium	High
	Miramar Landfill	N/A	N/A	N/A	N/A	Low	Medium
	CNG Fueling Station	N/A	N/A	N/A	N/A	Low	Low
	Beaches	High	Medium	High	Medium	Low	Medium
Additional Assets	Recreation centers	High	Low	N/A	Medium	Medium	Medium
	Libraries	N/A	N/A	N/A	N/A	Low	Medium
	City Buildings	N/A	N/A	N/A	N/A	Low	Medium
	Historical, Tribal Cultural, and Archaeological Resources	High	High	High	High	Medium	High

Consequences of these vulnerabilities could include:

- **Public Safety** – Many public safety assets are associated with key emergency services, such as fire stations and lifeguard stations, which face exposure to most or all hazards. If they are damaged, City services and human health could be affected. Delayed response times could increase the risk of loss of life or injury to people seeking emergency response, and facilities could be called to serve a larger area.
- **Water** – Impacts to wastewater systems could result in loss of the critical service of wastewater removal and treatment. Impacts to water systems could compromise access to clean water. Consequences could include damages to City services, human health and safety, and the environment.
- **Transportation** – Disruptions to transportation systems could delay or inhibit the movement of goods and people, which could reduce economic competitiveness and societal functioning. Emergency vehicles could also be delayed. The extent of damage will depend on the location and traffic load of the asset, and on the redundancy of the system.
- **Storm Water** – Damage to storm water infrastructure could exacerbate the impacts of flooding. Damage, disruption, or failure would primarily impact City services through responses to manage flood risk.
- **Open Space and the Environment** – If these assets are damaged, the City could lose resources that provide recreational opportunities, ecosystem services, and habitat value. There could be significant consequences to City services and natural resources and environment, in addition to some consequences to human health and social equity.
- **Additional Assets** – Recreation centers; libraries; City buildings; and historical, tribal cultural, and archaeological resources could also be damaged by climate-related hazards. Damages to these

assets could have consequences to City services or directly to historical, tribal cultural, and archaeological resources. For example, libraries play an important role in community cohesion, and are used as cooling centers during periods of extreme heat.

Table 5 provides a summary of the types of consequences that could result from damage, disruption, or failure of each critical asset type. For each critical asset class/type, a check mark indicates that damage to the critical asset type could result in a consequence for that consequence category. Each section in the report below provides more details on the potential consequences of impacts to each sector, with illustrative examples of the types of consequences that could occur if critical assets are damaged.

Table 5. Summary of Consequences of Asset Types Being Damaged, Disrupted, or Failing due to Climate Hazards

Sector	Critical Asset	Consequence Categories				
		City Services	Human Health	Social Equity	Historical, Tribal Cultural, and Archaeological Resources	Natural Resources and Environment
Public Safety Assets	Fire Stations	✓	✓		✓	
	Lifeguard Stations	✓	✓		✓	
	Fire Logistics and Dispatch	✓	✓			
	Maintenance Facilities	✓				
	Police Stations[10]	✓	✓	✓	✓	
	Police Patrol and Specialty Vehicles	✓	✓			
	Other Public Safety	✓	✓			
Water Assets	Dams	✓	✓		✓	✓
	Water Pipes	✓	✓			
	Wastewater Pipes	✓	✓			
	Water Pump Stations	✓	✓			
	Wastewater Pump Stations	✓	✓			
	Distribution Reservoirs	✓	✓			

[10] The "social equity" consequence for police stations refers to the Multicultural Storefront station. This is a Police building that is used constantly as a hub for citizens from other countries. It is a location for non-native-English speaking citizens to get services or directed to services, and for police to help with mediation of community groups.

Sector	Critical Asset	Consequence Categories				
		City Services	Human Health	Social Equity	Historical, Tribal Cultural, and Archaeological Resources	Natural Resources and Environment
	Water Treatment Plants	✓	✓			
	Wastewater Treatment Plants	✓	✓			✓
Transportation and Storm Water Assets	Airports	✓	✓		✓	✓
	Bridges	✓	✓	✓	✓	
	Major Arterials	✓	✓	✓		
	Drain Pump Stations	✓	✓	✓		
	Outfalls	✓	✓			✓
	Levees	✓	✓			
Open Space and Environment Assets	Conservation Areas/Open Space/Source Water Land	✓	✓		✓	✓
	Community Parks		✓	✓	✓	✓
	Miramar Landfill	✓	✓			
	CNG Fueling Station	✓				
	Beaches	✓	✓	✓	✓	✓
Additional Assets	Recreation centers	✓	✓	✓	✓	
	Libraries	✓	✓	✓	✓	
	City buildings	✓			✓	
	Historical, Tribal Cultural, and Archaeological Resources				✓	

Based on the findings of the Phase 1 assessment and consultations with stakeholders, individual critical assets were selected from highly vulnerable asset types for detailed risk profiles with targeted adaptation strategies. A suite of preliminary adaptation strategies was also developed. These strategies will be furthered refined during the development of *Climate Resilient SD*.

Support for this project comes in part from a California Coastal Commission Local Coastal Program Local Assistance Grant and a Caltrans Adaptation Planning Grant.

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Introduction

The City of San Diego faces both opportunities and risk from climate change. Sea level rise is occurring along the San Diego coast (Kalansky, Cayan, Barba, Brouwer, & Boudreau, 2018), and could lead to more extensive flooding and increased coastal erosion in the years ahead. Inland parts of the City experience periods of extreme heat, which are projected to intensify and become more frequent. To reduce negative impacts on City assets and services, the City is taking proactive steps to understand the risks posed by climate change hazards, identify critical vulnerabilities, and address them to ensure that San Diego remains a thriving and beautiful place to live, work, play, and visit.

Located in Southern California, San Diego is the second largest city in California, home to approximately 1.4 million people. The City boasts seventeen miles of coastline and a strong economy, with key industries such as international trade, manufacturing, military and defense, and tourism.

Figure 2. The primary climate change hazards considered in this vulnerability assessment are precipitation, heat, sea level rise, and wildfire—all of which pose risks to San Diego.

San Diegans are a culturally diverse population: over one-quarter of residents are Hispanic or Latinx, roughly one-sixth are Asian, and less than half are White (US Census Bureau, 2017). Historically, this region was home to the Kumeyaay people. The City's population is also economically diverse; approximately fifteen percent of San Diego's population lived below the federal poverty level in 2017 (US Census Bureau, 2019), while nearly ten percent of households in San Diego had incomes of more than $200,000 (Esri, 2018). Across the United States, Hispanic and Latinx populations are disproportionately vulnerable to and impacted by climate change. The same is true for Native American populations, and thus likely applies to the Kumeyaay people as well. This vulnerability seems to be tied to variables including location, employment type, income level, and access to resources (EDF, 2017; Lynn et al., 2011). As such, assessing vulnerability and defending against climate change is important for San Diegan, and is particularly crucial for its population of disproportionately vulnerable inhabitants.

The San Diego region is also known for its natural plants and animals and is considered a biodiversity hotspot. Many rare, threatened, and endangered plant and animal species call San Diego home, including the Torrey Pine, Southern sea otter, and Peninsular bighorn sheep (San Diego State University, 2005).

Assessing San Diego's Vulnerabilities to Climate Change Hazards

The City of San Diego Climate Change Hazard Vulnerability Assessment is focused on four primary climate change hazards that pose special risks to the City: sea level rise (including coastal flooding and erosion), extreme heat, changes in precipitation (including droughts and heavy rainfall), and wildfire.

Coastal Hazards

With seventeen miles of coastline that are critical to the region's economy, tourism industry, and San Diegan lifestyle, coastal hazards are a primary climate-related concern for San Diego. Coastal hazards include coastal flooding and erosion, both of which are expected to be exacerbated by climate change. Sea levels rose 0.71 feet in San Diego during the 20th century (NOAA, 2018). San Diego could experience another 0.8 feet of sea level rise by 2030, 1.6 to 2.4 feet by 2050, and 3.6 to 10.2 feet by 2100, depending on the rate of climate change and how the world's oceans and glaciers respond (California Coastal Commission, 2018). The frequency of extreme coastal floods is expected to increase under all projections of sea level rise. Rising seas boost the occurrence of severe floods (such as the 500-year flood) more than moderate floods (such as the ten-year flood) along the Pacific coast of the United States (Buchanan, 2017). By elevating storm tide, sea level rise makes it easier for waves to overtop natural barriers, increasing the relative frequency of flooding along the Pacific coast.

Coastal erosion has long been an issue in San Diego, affecting cliff areas such as Sunset Cliffs, La Jolla Cove, and Torrey Pines, as well as beaches. Ongoing erosion has required beach nourishment at certain locations to maintain beach width. Sea level rise and changes in storms are expected to increase coastal erosion, though the timing and specific locations of those impacts are unclear. In this report, "beach erosion" refers to erosion on any non-cliff shorelines.

Precipitation

The primary concerns for precipitation-driven hazards are historical flood areas and changes in annual and extreme precipitation. For the San Diego region, projections show only a slight change in average annual rainfall, but overall there is expected to be more variability in rainfall from year to year and more intense transitions between droughts and deluges (Higbee, 2014; Swain, 2018). Areas of San Diego already flood when there are heavy rainfall events. As rainfall events intensify in the future, inland areas affected by flooding could increase.

Heat

San Diego is known for its moderate temperatures: in the past, extreme highs (93 degrees Fahrenheit) have occurred only about four days per year. By the 2080s, extreme highs could occur up to 30 days a year. Average daily high temperatures are also projected to increase: while historically (1961 to 1990), the annual average daily maximum temperature for San Diego was 73.6 degrees Fahrenheit, climate model projections suggest an increase by mid-century (2035 to 2064) to 77.2 degrees Fahrenheit under a low emissions scenario and to 78.1 degrees Fahrenheit under a high emissions scenario (Cal-Adapt, 2018). By the late century (2070 to 2099), average temperatures are projected to reach 78.5 degrees Fahrenheit under the low emission scenario and 81.3 degrees Fahrenheit under the high emission scenario (Cal-Adapt, 2018). Heat waves are also projected to become more frequent and to last longer.

Wildfire

Historically, southwestern California has been a hot spot for wildfire. Climate change will likely increase all the key drivers of wildfires—high temperatures, dry conditions, and flammable vegetation. While there is uncertainty in wildfire modeling, the City of San Diego anticipates that future wildfire risk will be as severe as or more severe than that observed in recent decades (Kalansky, Cayan, Barba, Brouwer, & Boudreau, 2018).

More information on current and future climate conditions in San Diego is provided in Appendix A: Climate Data and Projections.

Report Overview

This Climate Change Vulnerability Assessment addresses the goal of gaining a comprehensive understanding of the City's climate change vulnerabilities. The assessment is a technical report that presents key findings from the vulnerability analysis and potential consequences of selected critical built, natural, and cultural assets to climate change hazards

This Vulnerability Assessment will provide the technical findings necessary to inform the development of the City's *Climate Resilient San Diego (Climate Resilient SD)* Plan. The need for a standalone climate adaptation plan was identified in the City's 2015 CAP.[11] Accordingly, the City is developing the *Climate Resilient SD* Plan to identify projected climate change hazards and responsibly address future conditions.

The *Climate Resilient SD* Plan's primary goals are to:

- Address climate equity by prioritizing and empowering our most vulnerable populations to climate change, with strong consideration of communities of concern;
- Raise awareness of projected/potential climate change impacts to the City;
- Gain a comprehensive understanding of the City's climate change vulnerabilities;
- Build City capacity for preventive and responsive action; and
- Identify potential climate adaptation and resilience strategies.

The remaining sections of this report describe the context, methodology, and findings of the vulnerability assessment, as follows:

- **The Vulnerability Assessment in Context:** Describes current and ongoing efforts by the City, organizations in the San Diego region, and the State of California to understand and prepare for climate change impacts;
- **Vulnerability Assessment Methodology:** Details the approach, data sources, and research questions used to assess City vulnerability;
- **Summary Vulnerability Assessment Findings:** Provides high-level findings across sectors and climate change hazards;
- The following sections provide detailed vulnerability findings by hazard for each analyzed sector:
    - **Public Safety;**
    - **Water;**
    - **Transportation and Storm Water;**
    - **Open Space and Environment;**
    - **Additional Assets**.

[11] City of San Diego (2015) *Climate Action Plan* https://www.sandiego.gov/sustainability/climate-action-plan.

- Non-City-Owned Resources: Presents the exposure of state-owned highways and freeways and privately-owned land within the City, categorized by land use type;
- Building Toward a Climate Resilient SD: Discusses plans for using the results of this vulnerability assessment to inform the larger City effort to develop a *Climate Resilient SD* Plan and explains next steps;
- Glossary: Defines key terms related to climate, adaptation, and resilience;
- References: Identifies references cited in this report;
- Acknowledgments: Recognizes the organizations and individual members of the Climate Resilient San Diego SAG;
- Appendices
    - Appendix A: Climate Data and Projections: Explains the science for current and future climate conditions in San Diego, considering the four key climate change hazards;
    - Appendix B: Hazard Maps: Shows where the priority hazards are expected to be experienced in the City;
    - Appendix C: Exposure Data: Provides more detailed information on the number of assets exposed to the various climate change hazards;
    - Appendix D: Energy Efficient Buildings: Provides a list of buildings identified by the City of San Diego as LEED certified (and therefore energy efficient).

Support for this project comes in part from a California Coastal Commission Local Coastal Program Local Assistance Grant and a Caltrans Adaptation Planning Grant.

The Vulnerability Assessment in Context

San Diego's vulnerability assessment and resilience efforts are being undertaken within the context of related initiatives at the City, regional, and state levels.

City Efforts

Under the CAP, the City has taken bold steps to mitigate impacts of climate change and to reduce its greenhouse gas emissions. *Climate Resilient SD* will complement and build upon these existing efforts. This vulnerability assessment is a foundational element of the *Climate Resilient SD* plan, providing technical information on important vulnerabilities created or exacerbated by four key climate change hazards to the City.

- The City of San Diego's CAP (2015) calls for promoting the City's prosperity and quality of life by building communities that are resilient to climate change, recognizing that some degree of climate change will occur regardless of the City's effort to reduce and mitigate greenhouse gas (GHG) emissions. Chapter 5 of the CAP specifically calls for the development of a standalone climate adaptation plan that will integrate and build upon the strategies and measures in the CAP. This vulnerability assessment will inform the development of the climate adaptation plan (Figure 3).
- The City of San Diego's *2018 General Plan Amendments* (2018) revised the General Plan's Public Facilities, Services and Safety Element to include goals and policies that address wildfire hazard severity zones and to integrate climate resilience and adaptation. These updates were completed in accordance with SB1241.

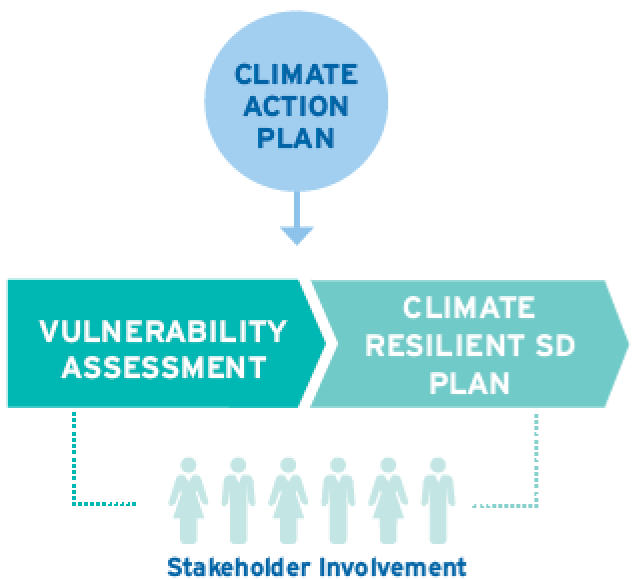

Figure 3. City of San Diego Climate Adaptation Work Interactions

Other Local Efforts

- The San Diego County *Multi-Jurisdictional Hazard Mitigation Plan* was last revised in 2017. The City of San Diego contributes a chapter to this plan, providing information on the City's critical facilities and potential exposures and losses related to climate change hazards including coastal storms and erosion, sea level rise, floods, rain-induced landslides, wildfire, and non-climate-related hazards such as earthquakes, dam failures, and tsunamis. The City's plan includes six hazard mitigation goals, along with objectives and prioritized action items to achieve them. The information relating to climate change hazards gathered by the City for the Hazard Mitigation Plan helped inform this vulnerability assessment and the hazard mitigation goals, objectives, and actions that can inform the *Climate Resilient SD* plan.

- The San Diego Urban Area *Threat and Hazard Identification and Risk Assessment* (SDUATHIRA) is a Department of Homeland Security/FEMA-mandated submission the City provides on a regular basis (one to three years) that identifies threats and hazards to which the region is vulnerable. In the City's latest submission, the sections on Wildfire and Utility Interruption (power outage) specifically mention the role of climate change on these vulnerabilities in the region. This report helps communities in the San Diego Urban Area better understand their risks and determine the level of capability needed to address those risks.
- The ICLEI-Local Governments for Sustainability *Sea Level Rise Adaptation Strategy for San Diego Bay* (2012) provides a high-level analysis of vulnerable sectors and impacts to the San Diego Bay lands. The study focused on flooding, inundation, erosion, saltwater intrusion, and water table rise. The study identified resilience strategies for both regional and local implementation, as well as strategies targeted to the sectors included in the analysis (ecosystems and critical species, contaminated sites, storm water management, wastewater, potable water, local transportation facilities, building stock, emergency response facilities, parks, recreation, and public access, regional airport operations, and vulnerable populations). The high-level vulnerability analysis helped inform this report, and the adaptation recommendations will help inform the *Climate Resilient SD* Plan.
- The ICLEI-Local Governments for Sustainability *San Diego Coastal Resilience Assessment* (2017) is a local sea level rise vulnerability assessment that included the coastal areas from Point Loma to Del Mar, excluding Mission Bay. The assessment identified sea level rise coastline impacts related to changes in flood frequency and extent, inundation, changes in sedimentation supply and movement, high rate of erosion, and saltwater intrusion and groundwater inundation. The assessment focused on building stock, the social sector, storm water, wastewater, water, transportation, beaches and public access, and biodiversity and habitat. These findings helped inform this vulnerability assessment with respect to coastal hazards.
- The Scripps Institute of Oceanography *Beach and Coastal Cliff Survey* (ongoing) is currently collecting data on beach sand levels from La Jolla Shores Beach to Oceanside. These data can provide greater insight into coastal hazards, which are considered in this vulnerability assessment.
- From 2013 to 2019, the City of San Diego partnered with the U.S. Bureau of Reclamation to complete the *San Diego Basin Study*. This study uses the latest climate change modeling tools to perform a quantitative analysis of the uncertainties associated with climate change impacts on the San Diego Basin's local and imported fresh water supplies. A goal of this study is to assist water agencies serving the Basin and San Diego Integrated Regional Water Management planning region in adapting to climate change-related uncertainties.
- The *San Diego Regional Climate Collaborative's Resilient Coastlines Project* (ongoing) is building coastal resilience in the region by translating sea level rise and coastal storm science into planning, building local leadership, and holding living shorelines workshops.

State Guidance and Resources

The following state guidance is applicable to the City's resilience planning efforts:

- The California Ocean Protection Council and California Natural Resources Agency's State of California Sea-Level Rise Guidance 2018 Update (2018) provides: "1) a synthesis of the best available science on sea level rise projections and rates for California; 2) a stepwise approach for state agencies and local governments to evaluate those projections and related hazard information in decision-making; and 3) preferred coastal adaptation approaches."
- The Governor's Office of Planning and Research, California Natural Resources Agency, and California Energy Commission's California's Fourth Climate Assessment (2018) was designed "to address critical information gaps that decision-makers need at the state, regional, and local levels to protect and build resilience of California's people and its infrastructure, natural systems, working lands, and waters." The City is using findings published in the Fourth Assessment that pertain to sector vulnerability, sensitivity, and adaptive capacity.
- The California Natural Resources Agency's Safeguarding California (2018) is "the State's road map for everything state agencies are doing and will do to protect communities, infrastructure, services, and the natural environment from climate change impacts." The City is using this resource to help coordinate adaptation with state efforts and to find examples of adaptation strategies.
- The California Coastal Commission's Sea Level Rise Policy Guidance (2018) provides the best available science on sea level rise specific to California, paired with a recommended methodology for addressing sea level rise in Coastal Commission planning and regulatory actions. The City followed this guidance in assessing its vulnerabilities to sea level rise.
- The Governor's Office of Emergency Services' California Adaptation Planning Guide (2012) provides guidance for local jurisdictions in addressing climate change impacts. The City referred to this guide when developing its framework for adaptation planning. The City is also working with the Governor's Office to inform the development of the updated California Adaptation Planning Guide planned for publication in 2020.

Vulnerability Assessment Methodology

The City is composed of departments, each with a responsibility for the management of particular assets, operations, and services that help the City function and thrive. To gain a comprehensive understanding of the priority concerns posed by climate change to the City's selected priority assets, the vulnerability assessment was conducted in two phases:

- Phase 1 was a screening-level vulnerability assessment of selected critical City asset types. This entailed assessing the exposure of critical asset types to each hazard, then analyzing the sensitivity and adaptive capacity of exposed critical asset types. The City also assessed the consequences of climate change impacts to each sector.
- Phase 2 involved developing detailed risk profiles for selected individual assets that if damaged or lost would have significant consequences to the City. Assets were selected based on the findings of Phase 1 and consultations with stakeholder advisors and City departments.

The vulnerability assessment's findings will inform the development of City-wide climate change adaptation strategies.

This report covers Phase 1 of the vulnerability assessment, which the City conducted using quantitative and qualitative hazard and asset data along with input from its SAG (described on page 32).

Vulnerability vs. Consequences

Vulnerability: "…[The] degree to which a system is exposed to, susceptible to, and unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, including its sensitivity, and its coping and adaptive capacity." (California Coastal Commission, 2018)

Consequences: Impacts on community structures, functions, and populations, and on asset owners' or service providers' ability to maintain a standard condition or level of service (CEMA and CNRA, 2012).

Data Collection and Consultation

The City began this analysis by compiling and reviewing existing information on climate vulnerability and climate change hazard projections for the San Diego region. The analysis provided an understanding of the current state of knowledge, identified remaining information gaps, and summarized the actions the City is already taking to prepare for and respond to climate change.

Collecting and Mapping Climate Change Hazard Data

The City collected data for past, present, and projected future climate change hazards from the best available scientific sources. These include the California Coastal Commission, the U.S. Geological Survey's Coastal Storm Modeling System (CoSMoS), Cal-Adapt (the state's central resource for climate science), the Federal Emergency Management Agency (FEMA), the CalEPA, and internal City data sources for information on past exposure, such as areas that have historically flooded or been exposed to wildfire.

Appendix A provides detailed information on the selection of hazard scenarios; an overview of data sources for each climate change hazard analyzed is provided below.

The City collected and analyzed data on the following hazards:

Sea Level Rise

- **Coastal Flooding**

  According to the November 2018 update to the California Coastal Commission's (CCC) *Sea Level Rise Policy Guidance,* sea levels in San Diego may rise by 0.6 to 1.1 feet (0.25 m) by 2030, 1.2 to 2.8 feet (0.5 to 0.75 m) by 2050, and 3.6 to 10.2 feet (1 to 2 m) by 2100 (California Coastal Commission 2018). The City used this information to select corresponding data from localized sea level rise modeling produced by CoSMoS, which were used to develop exposure maps. CoSMoS provides maps of coastal flooding that could result from sea level rise and storms while factoring in changes in beaches and the retreat of cliffs and bluffs along the California coast (USGS, n.d.). Table 6 shows how the CCC 2018 projections were translated to the closest data available from CoSMoS.

  Based on this data selection process, the City used the following sea level rise projections to estimate the exposure from daily average flooding and storm surge (100-year) flooding: 0.25 m of sea level rise (0.8 feet) (2030 timeframe), 0.5 m and 0.75 m of sea level rise (1.6 to 2.5 feet) (2050 timeframe), and 1.0 m, 1.5 m, and 2.0 m of sea level rise (3.3 to 6.5 feet) (2100 timeframe). Daily flooding was used to estimate exposure to chronic inundation and represents the extent of flooding that would occur at high tide on average each day assuming each sea level rise scenario. Storm surge (100-year storm) flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm assuming each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

  The sensitivity and adaptive capacity ratings of the sea level rise with storm surge flooding focuses on the temporary duration of extreme flood scenarios, while sea level rise alone focus on the impacts of chronic inundation. Thus, while the area expected to be exposed to sea level rise with storm surge flooding is greater, the impacts of periodic storm-based flooding are generally less than the impacts of chronic flooding. Generally it is easier to prepare for periodic flooding than for chronic flooding.

Table 6. Coastal Flooding Scenario Selection Based on CCC 2018 Projections and Closest CoSMoS Increments

Year	Low Risk Aversion Scenario[12] 17% probability SLR meets or exceeds		Medium-High Risk Aversion 0.5% probability SLR meets or exceeds		Extreme Risk Aversion Scenario H++ scenario, no assigned probability	
	CCC 2018 Projection	Closest CoSMoS Increment	CCC 2018 Projection	Closest CoSMoS Increment	CCC 2018 Projection	Closest CoSMoS Increment
2030	0.6 ft.	0.25 m (0.8 ft.)	0.9	0.25 m (0.8 ft.)	1.1 ft.	0.25 m (0.8 ft.)
2050	1.2 ft.	0.25 m (0.8 ft.)	2.0 ft.	0.5 m (1.6 ft.)	2.8 ft.	0.75 m (2.5 ft.)
2100	3.6 ft.	1 m (3.3 ft.)	7.0 ft.	2 m (6.6 ft.)	10.2 ft.	2 m (6.6 ft.)

- Coastal Erosion

  The relatively soft sandstone bluffs that are common along the San Diego coast are prone to erosion from waves and from storm water runoff. In addition, sea level rise together with increased storm frequency may accelerate beach and other shoreline erosion. The last City-wide coastal erosion assessment, consisting of geotechnical reports, site visits, and photographic documentation of erosion, was completed in 2003 (City of San Diego 2003). The City worked with consultants to update this coastal erosion assessment in 2018 and found that while the City has made improvements to pedestrian access and safety along the erosion sites, additional sites pose threats to pedestrian access or safety.

  Based on this identified vulnerability, the City selected the best available localized modeling from CoSMoS for coastal erosion in the area, covering shoreline and cliff retreat under a Medium-High Risk Aversion Scenario of 2.0 m of sea level rise by 2100 (see Table 6) for four scenarios (USGS, n.d.):

  - Beach erosion:
    - "No hold, no nourish" assumes the shoreline is allowed to retreat unimpeded and with no human increases in sediment (i.e., beach nourishment).

[12] The recent California Coastal Commission Sea Level Rise Policy Guidance November 2018 update provides three sets of sea level rise projections: low, medium-high, and extreme risk aversion. The sea level rise projections associated with low risk aversion should be used to inform planning for development with high adaptive capacity and relatively low associated consequences if impacted by sea level rise, such as temporary or seasonal development, or development that can be easily moved. The projections labeled "medium-high risk aversion" are appropriate for informing less adaptive, more vulnerable land uses that will experience medium to high consequences if impacted by sea level rise, including residential and commercial development. The projections labeled "extreme risk aversion" and "H++" are appropriate for development that, if impacted by sea level rise, would be irreversibly destroyed, would be significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts—such as critical infrastructure.

- “Hold, continued nourish” assumes the shoreline retreat is limited to an urban boundary and sediment is increased.
- Cliff retreat:
  - “Let it go” avoids coastal armoring and allows the cliff to retreat and cliff erosion rates to increase as sea level rises.

For the purpose of this assessment, beach erosion considers erosion of non-cliff shorelines, while cliff retreat considers erosion of cliffs along the coastline.

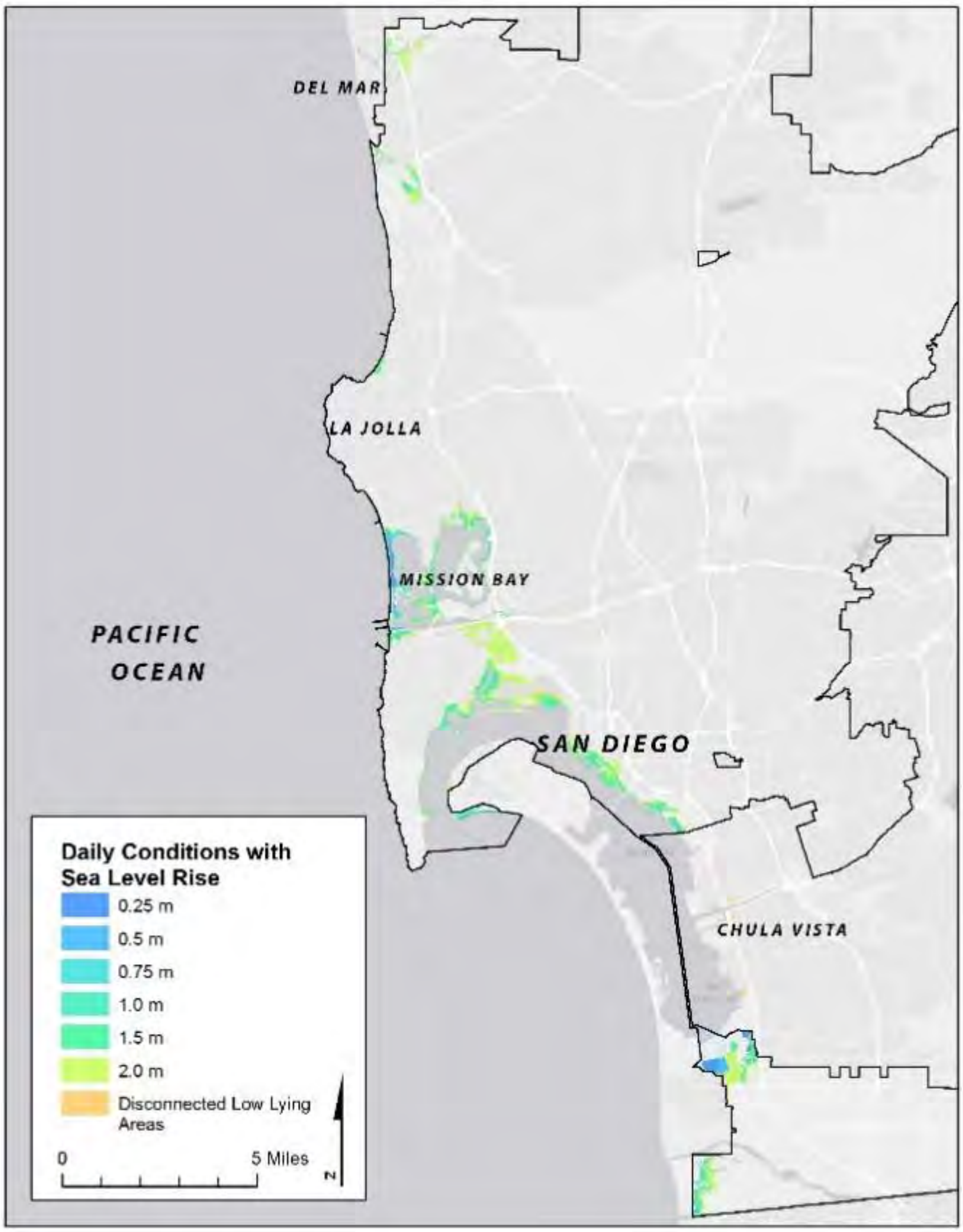

Figure 4. Daily coastal flooding in the City of San Diego given varying sea level rise scenarios. Flooding data obtained from USGS. Maps created: 2019.

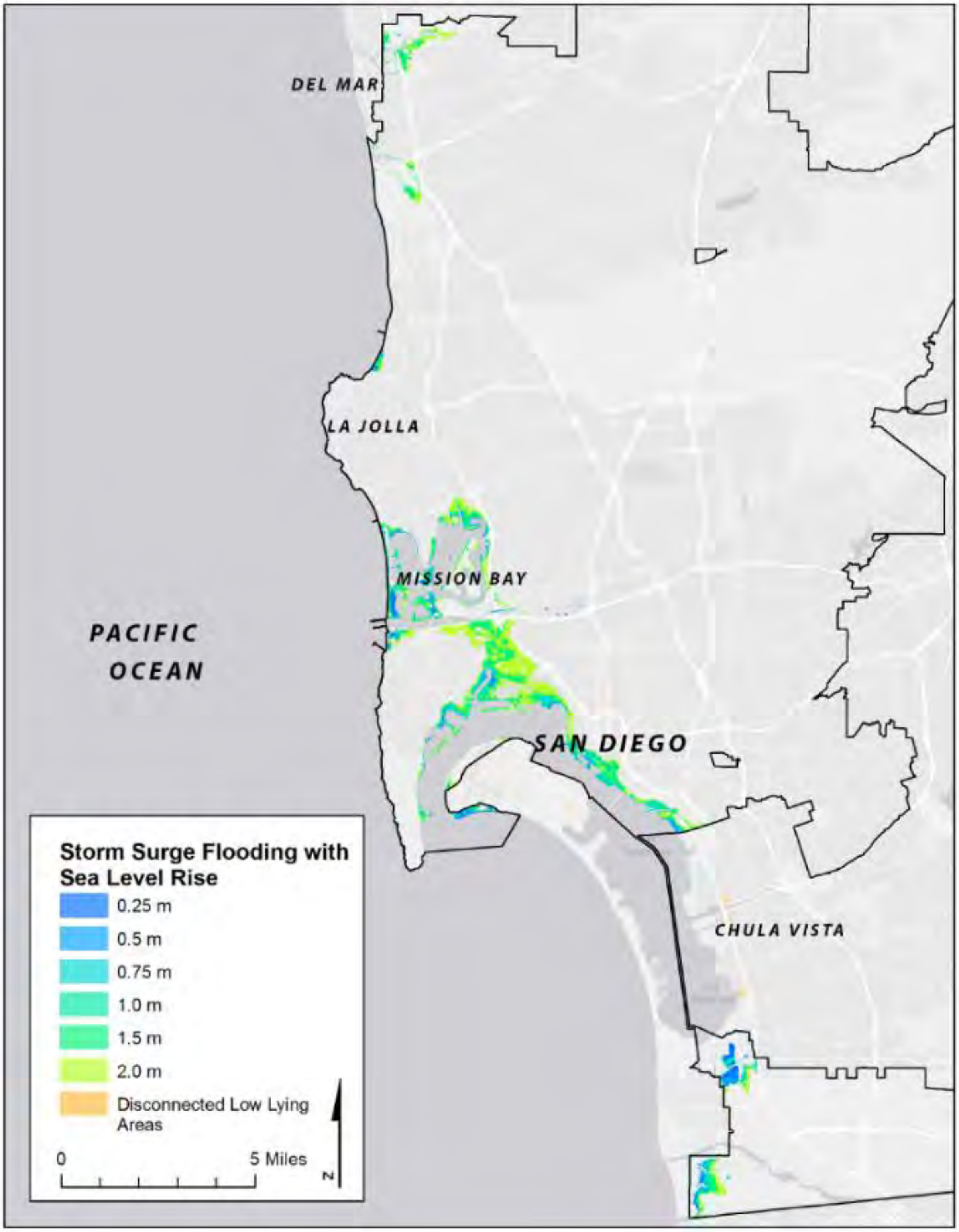

Figure 5: Storm surge (100-year) coastal flooding in the City of San Diego given varying sea level rise scenarios. Flooding data obtained from USGS. Maps created: 2019.

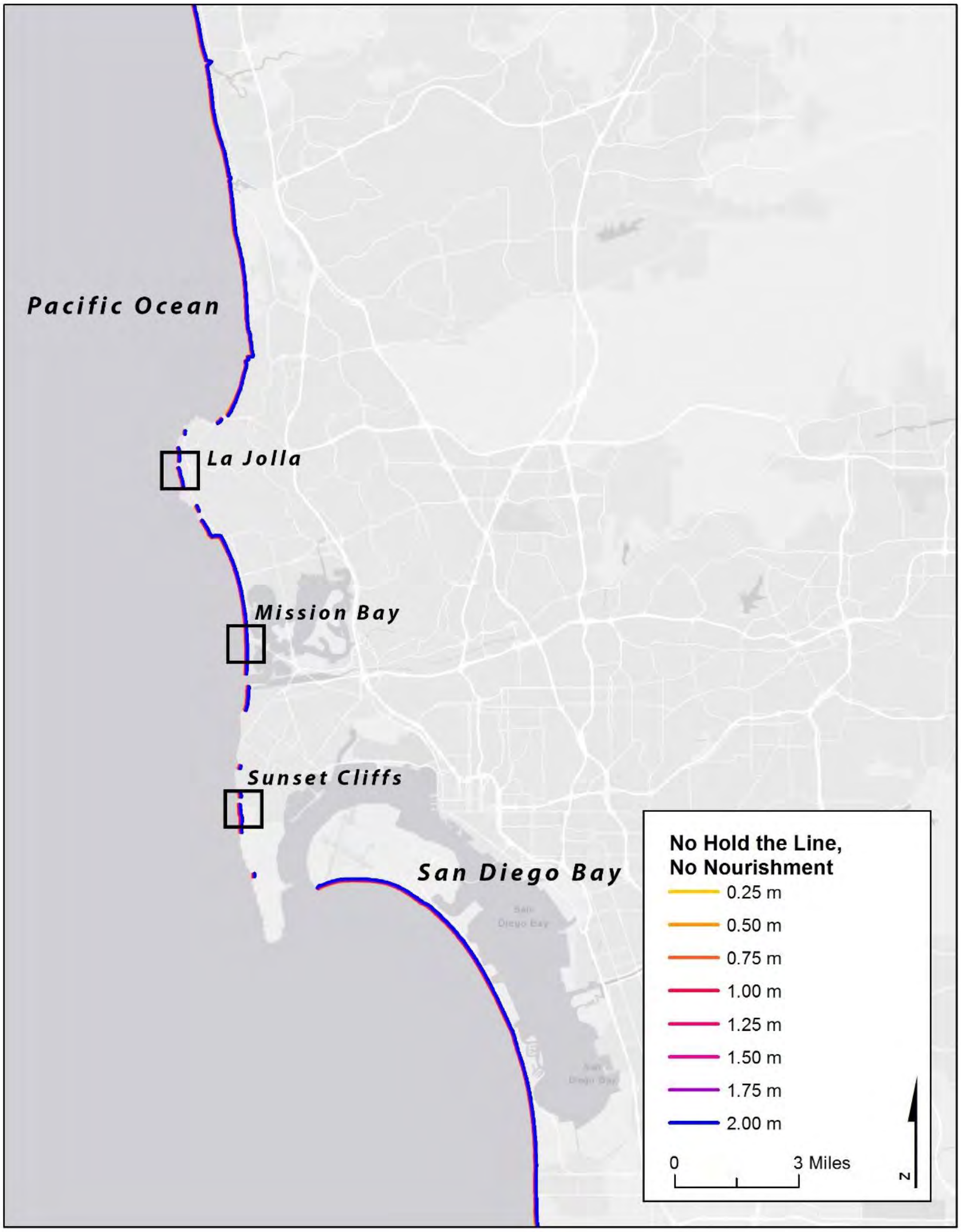

Figure 6. Beach erosion in the City of San Diego under the no hold the line, no nourishment scenario. Erosion data obtained from USGS. See Appendix B: Hazard Maps for the scaled-up insets at La Jolla, Mission Bay, and Sunset Cliffs. Map created: 2019.

Changes in Precipitation

Annual average precipitation projections from Cal-Adapt and other sources suggest only modest changes in total annual precipitation in the decades ahead (Seager, 2015), but there is expected to be more variability in rainfall from year to year and more intense transitions between droughts and deluges (Swain, 2018). This is in part due to an expected intensification of atmospheric rivers, which are often responsible for extreme precipitation events that punctuate dry spells in Southern California (Kalansky, Cayan, Barba, Brouwer, & Boudreau, 2018). To examine potential flooding vulnerabilities from intense precipitation events, the City selected the best available spatial data that reflect current, highly localized precipitation-driven flood vulnerability: the 100-year floodplain and 500-year floodplain from the Federal Emergency Management Agency Flood Insurance Rate Maps (FIRMs) (FEMA, 2016). These reflect 2012 FIRMs for all of the City except South Bay, for which the FIRM was last updated in 2016.

Extreme Heat

The City used urban heat island index data from CalEPA to project areas that could be exposed to extreme heat. These data were the best available spatial information for heat within the City at the time of the vulnerability assessment. The geographic patterns revealed by CalEPA's urban heat island data are likely to persist even as temperatures change over time. This source thus identifies areas of the City that are likely to be more or less vulnerable to future extreme heat events. In general, these data show that areas near the coastline are cooler, and temperatures increase moving inland. The heat island scenarios are represented as zones with scores of 0 to 100+, with higher scores denoting hotter areas (CalEPA, 2019).[13] A score of zero indicates that there is no difference in temperature over time between an urban Census tract and nearby upwind rural reference points. A score of 100 indicates that there is a difference of 7.5 degrees Fahrenheit (approx. 4.2 degrees Celsius) between these tracts over 24 hours.

Wildfire

The City of San Diego used a conservative approach to plan for a future wildfire risk of equal or greater severity than that of recent decades. The City based its wildfire vulnerability assessment on its four current measures of fire risk: The City's brush management zone, a 100-foot and 300-foot buffer around the brush management zone, and the fire hazard severity zone. These areas indicate where fuel for potential wildfires exists within the City.

[13] The urban heat island index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period. To estimate the total number of degrees Fahrenheit per day, divide the Index by 24 hours and multiply by 1.8 degrees. Higher scores denote hotter areas.

Figure 7. Precipitation exposure to the 100-year and 500-year floods in the City of San Diego. Floodplain data obtained from FEMA. These reflect 2012 FIRMs for all of the City except South Bay, for which the FIRM was last updated in 2016. Map created: 2019.

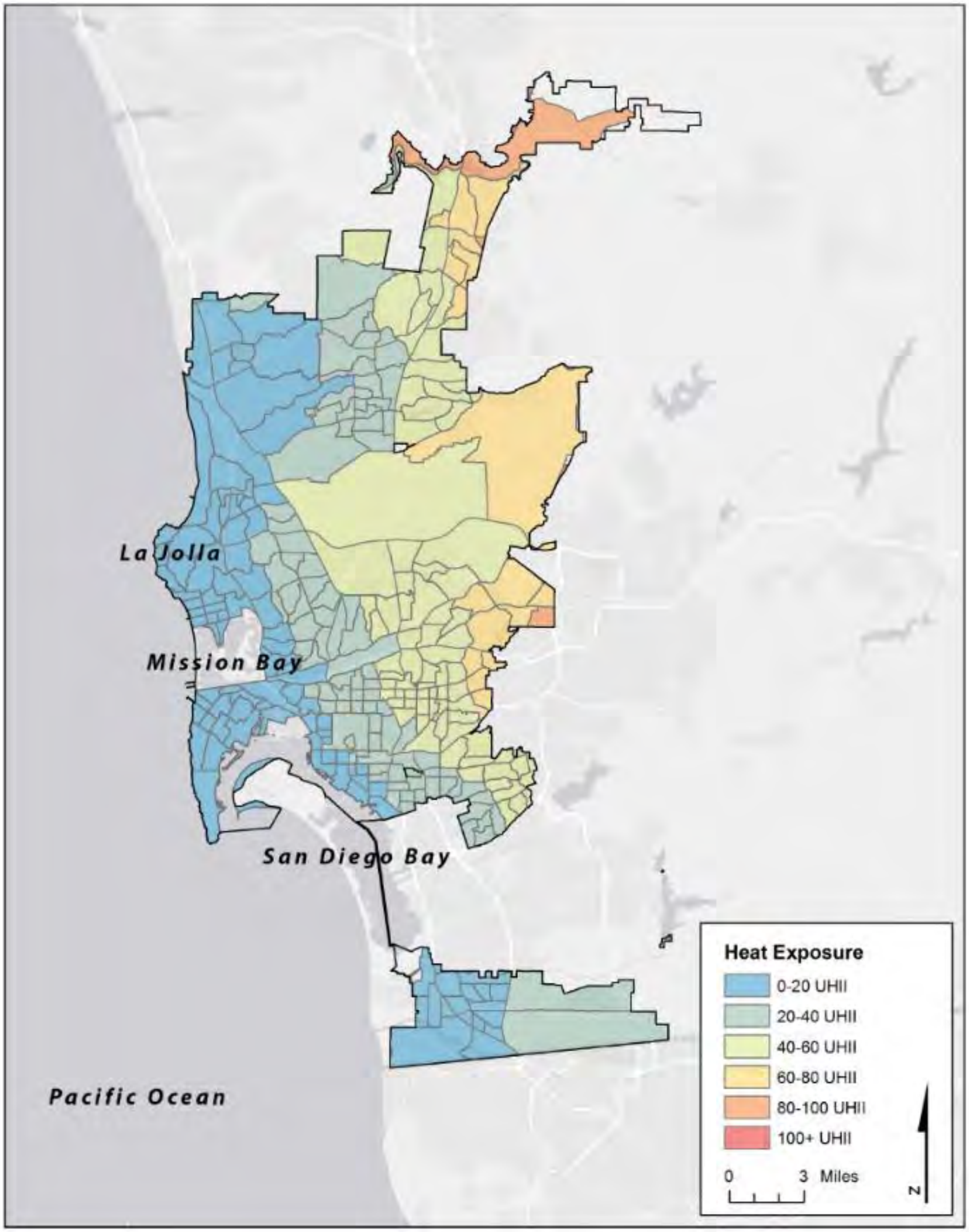

Figure 8. Urban heat island zones in the City of San Diego. Urban heat island data obtained from CalEPA. Map created: 2019.

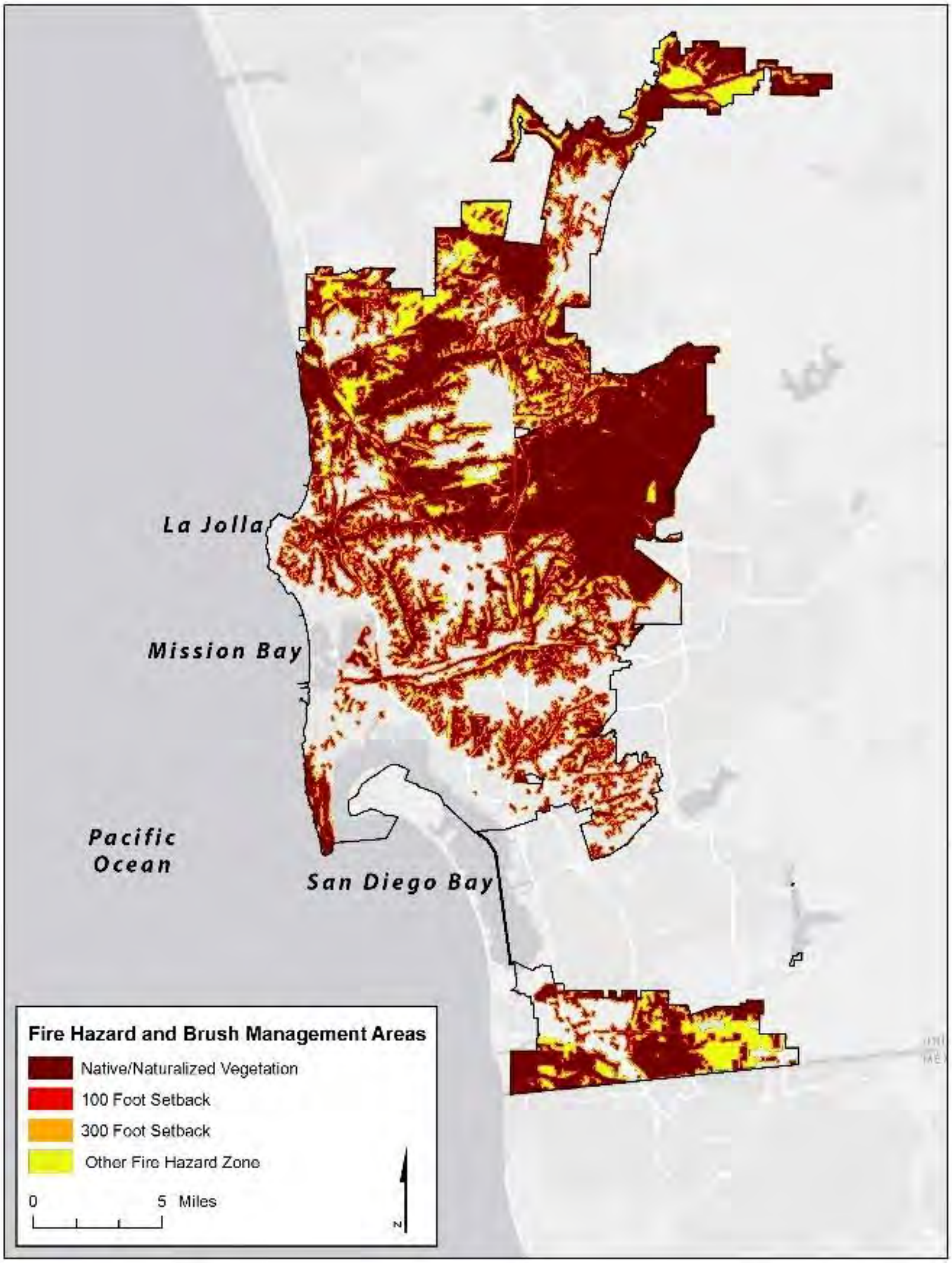

Figure 9. Wildfire hazard zones in the City of San Diego. Fire zone data obtained from the City of San Diego. Map created: 2019.

Selecting Critical City Assets

At the outset of this assessment, the Planning Department consulted other City departments to identify which built, natural, and cultural asset types owned and/or managed by the City could be considered critical. The selection criteria were:

- If the asset type/resource (or its function) is necessary for continuity of important City operations;
- If the asset type/resource (or its function) is a key driver in the City's economy;
- If loss of the asset type/resource would present equity issues;
- If the asset type/resource is critical to safeguarding biological diversity and other environmental priorities.

Table 7 provides a breakdown of the sectors that were considered, the responsible City departments, and the specific asset types that were identified as critical. Only critical asset types are included in the vulnerability assessment. Not all critical asset types in this list were found to be exposed to climate hazards.

Table 7. City of San Diego Departments and Corresponding Critical Assets

Sector	City Department(s) (or other managing entity)	Critical Asset Types
Public Safety	Fire-Rescue, Police	Fire stations, police stations, lifeguard stations, police patrol and specialty vehicles, maintenance facilities, other public safety assets (Critical Incident Management Unit equipment locations, police evidence storage buildings, police vehicle maintenance, police trailers, portable fire station trailers, logistics and dispatch facilities, DRC emergency operations, police air support hangers, multicultural storefront[14])
Water Infrastructure	Public Utilities	Dams, water pipes, wastewater pipes, water pump stations, wastewater pump stations, distribution reservoirs, water treatment plants, wastewater treatment plants
Transportation[15]	Transportation and Storm Water; Real Estate Assets	Major arterials, Brown Field Municipal Airport, Montgomery-Gibbs Executive Airport, bridges

[14] The multicultural storefront is a Police building that is used constantly as a hub for citizens from other countries. This is a location for non-native-English speaking citizens to obtain services or to be directed to services, and for police to help with mediation of community groups.

[15] Bridges and major arterial assets were broken down into roadway segments as defined in the City's asset management system.

Sector	City Department(s) (or other managing entity)	Critical Asset Types
Storm Water	Transportation and Storm Water	Drain pump stations, outfalls, levees (These critical assets included in the analysis are part of a larger storm water conveyance system of pipes and channels)
Open Space/ Environment	Parks and Recreation, Environmental Services; Public Utilities	Conservation areas/open space/source water land,[16] community parks, Miramar Landfill, CNG fueling station, beaches
Additional	Real Estate Assets; Parking Organization; Commission for Arts and Culture	Recreation centers, libraries, City buildings, historical, tribal cultural, and archaeological resources

In addition to these critical City assets, the assessment also considered the exposure of certain non-City asset types to give a more holistic view of climate change risks. Specifically, state highways and freeways are assessed for exposure to provide a more comprehensive view of the transportation network serving the City. Vulnerability scores were not calculated for these assets, as the City does not have full insight into the sensitivities and adaptive capacities of assets it does not manage.

Each private parcel was assigned one or more land use type based on the tax assessors' land use code. The City identified seventy-two building types and grouped them into seventeen land use categories: agricultural, commercial, community, cemetery, entertainment, health, hotel/motel, industrial, institutional, marina docks, office space, open space, residential, restaurant, rural, not defined, and vacant.

Establishing a Stakeholder Advisory Group

The City formed a Stakeholder Advisory Group (SAG) with diverse representation from regional stakeholders, including internal City departments, State and federal agencies, local nonprofit and environmental organizations, community-based organizations, transportation agencies, energy utilities, academic institutions, and other key stakeholders (see the Acknowledgments section for a list). The SAG was created to provide feedback and input at key points in the vulnerability assessment and *Climate Resilient SD* planning process.

[16] "Source water land" refers to open space land managed by the Public Utilities Department that serves the primary purpose of capturing and protecting native source water.

The City held a SAG kickoff meeting on December 17, 2018, during which the City introduced SAG members to the City's climate resilience efforts and the need for stakeholder involvement. At the first stakeholder workshop on April 9, 2019, the City presented the initial findings of this vulnerability assessment to the SAG. The stakeholders provided feedback based on their experience and knowledge of vulnerabilities and assets. The workshop included brainstorming sessions where the City worked alongside stakeholders to draft possible adaptation strategies for the identified vulnerabilities. At the second stakeholder workshop on September 19, 2019, the City presented its framework for evaluating the adaptation strategies and worked with stakeholders to utilize the framework to evaluate potential adaptation strategies. The stakeholders help to vet the evaluation criteria and provide feedback on what criteria were important to consider.

Vulnerability Analysis

This report details the findings of Phase 1 of the City vulnerability assessment, which included an asset type level screening for vulnerability and consequences. Vulnerability is assessed by evaluating exposure, sensitivity, and adaptive capacity. Consequences are the potential impacts to the City, the public, the economy, and the environment if the asset type were exposed to climate change. The following sections describe the methodology used to assess and score each of these components.

Exposure

Exposure: The presence of people, infrastructure, natural systems, and economic, cultural, and social resources in areas that are subject to harm (Bedsworth, 2018) citing (IPCC, 2012).

The goal of the exposure assessment was to understand which selected critical City asset types could be subject to the hazards considered in this analysis and which scenarios would lead to exposure (e.g., would a particular asset type experience flooding at 0.25 m or only at 2 m of sea level rise?).

To determine exposure, the project team overlaid geospatial climate change hazard data with the locations of critical assets. This information was then used to calculate how many individual assets would be exposed under each scenario. The project team obtained spatial data for projected climate change hazards from the USGS Coastal Storm Modeling System (CoSMoS), FEMA, the City of San Diego, CalEPA, and SanGIS through the SanGIS Regional Data Warehouse.

The exposure score for each type of critical asset (e.g., for all police stations) was based on the highest level of exposure experienced by any asset within that group. For example, for the fire station asset type, if one fire station was found within the FEMA 100-year floodplain for precipitation and received an exposure score of "high," then fire stations as a whole asset type were scored as "high" for their exposure to precipitation-based flooding. The breakdown of scoring for each hazard is shown in Table 8.

Table 8. Rubric for Scoring Exposure of Critical Asset Types to Climate Hazards

	Coastal Erosion	Coastal Flooding[17]	Precipitation	Heat	Wildfire
High	Within the zone eroded under the "Shoreline hold, continued nourish" CoSMoS beach erosion scenario with 2 m sea level rise	Within the zone inundated by the 0.25 m CoSMoS sea level rise scenario (2030)	Within the zone flooded by the FEMA 100-year floodplain	Within the zones with heat score of UHI[18] 80 to 100+	Within the native vegetation zone or its 100-ft buffer
Medium	Within the zone eroded under either the "Cliff let it go" cliff erosion *or* "Shoreline no hold, no nourish" beach erosion scenarios with 2 m sea level rise	Within the zone inundated by the 0.5 to 0.75 m CoSMoS sea level rise scenario (2050)	Within the zone flooded FEMA 500-year floodplain	Within the zones with heat score of UHI 40 to 80	Within the 300-ft buffer of native vegetation
Low	N/A (no low score for erosion)	Within the zone inundated by the 1.0 to 2.0 m CoSMoS sea level rise scenario (2100)	N/A (no low score for precipitation)	Within the zones with heat score of UHI 0 to 40	Within the fire hazard zone outside of brush management zone

Sensitivity

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli (California Coastal Commission, 2018).

The sensitivity analysis aimed to identify potential impacts to critical asset types that could be exposed to the climate change hazards considered in this assessment. Information on critical asset type sensitivity was gathered from relevant literature.[19] The project team also gathered City-specific information on asset sensitivity by holding interviews with City departments[20] and reviewed documentation collected by City

[17] Coastal flooding refers to both daily flooding and the 100-year storm given the various sea level rise scenarios.
[18] The urban heat island (UHI) index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree Celsius over an eight-hour period would equal eight degree-hours, as would an increase of two degrees Celsius over a four-hour period. Higher scores denote hotter areas.
[19] A full list of sources is presented in the References section at the end of this report.
[20] Parks and Recreation, Chief Operating Officer Homelessness Strategies, Office of Homeland Security, Risk Management, Debt Management, Department of Finance, City Treasurer, Sustainability, Fleet Services, Purchasing and Contracting, Human Resources, Transportation and Storm Water (TSW), Public Works (PW), Public Utilities

departments pertaining to previous emergencies and natural hazard impacts. These documents, such as Initial Damage Estimates (IDE) drawn up in the aftermath of FEMA-declared disasters, provided information such as the type of hazard experienced, level of damage, costs incurred, and asset condition.

The City scored sensitivity based on the highest assumed sensitivity within each critical asset type. For example, flooding from precipitation has historically led to mild to medium damage to fire stations, with more severe damage occurring when water enters drywall. This higher end of potential damage resulted in fire stations having a medium sensitivity to precipitation. The rubric for scoring sensitivity is shown in Table 9.

Table 9. Rubric for Scoring Sensitivity of Critical Asset Types to Climate Hazards

Score	Rationale
High	If exposed, the asset type may become damaged beyond repair or destroyed and cannot resume normal function until replaced.
Medium	If exposed, the asset type may be damaged such that repairs are necessary before it can resume full functionality.
Low	If exposed, the asset type may suffer minor damage but can maintain functionality or is not damaged at all.

Adaptive Capacity

Adaptive Capacity: The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences (California Coastal Commission, 2018) citing (Willows, 2003).

The goal of the adaptive capacity analysis was to identify actions the City has already taken and put in place to prepare for current and future natural hazards, as well as to understand the potential for further adaptive action. Adaptive actions are assumed to reduce vulnerability by avoiding exposure or reducing sensitivity to exposure. This can occur through physical protection measures, operational changes to avoid exposure, changing the nature of an asset so that it is less sensitive to exposure, and other strategies.

The City has a history of proactively managing extreme weather events. This includes being an active contributor to the County Hazard Mitigation Plan, last updated in 2018, under which the City developed specific goals, objectives, and actions to mitigate climate change hazards. Many of these actions are ongoing and are currently being implemented, such as:

- Creating fire buffer zones around residential and non-residential structures and other infrastructure systems by removing or reducing flammable vegetation;

(PUD) Environmental Services (ESD), Real Estate Assets (READ), Police, Fire-Rescue, and Development Services (DSD).

- Installing and maintaining permanent alternative power generators at all water and wastewater treatment plants and pumping stations;
- Updating the Land Development Code to require private development in the Coastal Zone to account for anticipated sea level rise;
- Restoring the conveyance capacity of key channels;
- Conducting staff training in the City's Emergency Operations Center (City of San Diego, 2017a).

The City held internal consultations and analyzed asset management data to understand the ability of critical assets to adapt to climate change hazards and to determine where adaptive measures or practices are already in place or planned. To assess adaptive capacity, City departments were asked whether:

- Any assets are made of materials that are particularly susceptible to damage from climate exposure;
- The assets could be moved when extreme weather events occur;
- The department currently deploys protective measures to prevent exposure during extreme weather events;
- Any backup features are available to maintain functionality if some assets become damaged; and
- Any additional current or planned action to address climate change hazards.

The City scored adaptive capacity based on the rubric in Table 10. Adaptive capacity has an inverse relationship to vulnerability, whereas exposure and sensitivity have a direct relationship with vulnerability. High exposure, high sensitivity, and low adaptive capacity contribute to high vulnerability, whereas low exposure, low sensitivity, and high adaptive capacity contribute to low vulnerability.

Table 10. Rubric for Scoring Adaptive Capacity of Critical Asset Types to Climate Hazards

Score	Rationale
High	The asset can easily be protected from climate impacts (e.g., there are already protective measures in place that adequately prevent impacts; assets can be moved during an event; there are backups available; the system or asset type has redundancies).
Medium	The asset can be protected with some effort (e.g., there are potential protective measures, but they are not yet in place; the asset needs to be retrofitted or upgraded to withstand impacts; backups need to be acquired from other jurisdictions during an event). While short-term options are available, longer-term or more permanent measures are more difficult to achieve.
Low	The assets cannot be protected (e.g., they are located within an exposed area and cannot be easily moved; there is no level of protection that can fully prevent damage; they are made of sensitive materials and cannot be upgraded; there are no backups available; possible adaptation measures are prohibitively expensive).

Bringing it all Together to Assess Asset Vulnerability

Vulnerability is a function of exposure, sensitivity, and adaptive capacity. The City combined the scores for these three components to determine a vulnerability score for each type of critical asset for each climate change hazard (that is, scores were assigned to the asset type level and not to individual assets).

Scores were assigned at the *asset class* level and not to individual assets, and were determined as follows:

- If all three components contributed to low vulnerability (low exposure, low sensitivity, high adaptive capacity), then the vulnerability score was low;

- If all three contributed to high vulnerability (high exposure, high sensitivity, and low adaptive capacity), then the vulnerability score was **high**;
- If all were medium, then the vulnerability score was **medium**;
- Two component scores that contributed to high vulnerability warranted a **high** vulnerability score;
- Two component scores that contributed to low vulnerability warranted a **low** vulnerability score if the third component was medium, and a **medium** vulnerability score if the third component was a high vulnerability score.

Consequences Screening

Consequence: The outcome, either positive or negative, of an event (ISO, 2018).

The goal of the consequences screening was to understand the types of potential outcomes that could occur due to damage, disruption, or failure of assets, focusing on outcomes that would interfere with achieving City objectives. Consequences were assessed across the set of categories listed and described below. These categories were selected based on a review of best practices found in municipal climate risk assessments, which focus on identifying consequences to municipal objectives and priorities. Categories were also selected based on priority City functions, including the provision of City services, public health and wellbeing, social equity, community and cultural support, and environmental protection.

Historical, tribal cultural, and archaeological resources were identified as a consequence category as well as an asset type, because these resources can be found across all sectors. The City's register of designated historical resources includes libraries, police facilities, dams, water storage and pumping stations, airport facilities, bridges, roads, cemeteries, and archaeological and tribal cultural resources within parks and open space areas. Thus, impacts to these asset types may also result in impacts to historical, tribal cultural, and archaeological resources, which must be acknowledged, understood, and planned for.

The City screened for consequences by considering the impacts of asset damage, disruption, or failure to the following categories:

- **City Services** (e.g., whether City departments would still be able to service the community, and which critical emergency services would be affected);
- **Human Health** (e.g., whether impacts to assets would result in loss of life, injury, disease, or hospitalization);
- **Social Equity** (e.g., how impacts to assets would affect the community, particularly vulnerable communities);

- **Historical, Tribal Cultural, and Archaeological Resources** (e.g., whether impacts to assets would affect the cultural identity of San Diego through damage to or loss of historical, tribal cultural, or archaeological resources);
- **Natural Resources and the Environment** (e.g., which habitats, species, and/or ecosystem services[21] would be lost, and how impacts to assets would affect local and regional biodiversity and ecosystem health).

In most cases, the consequences identified would be due to damage, disruption, or failure of critical assets, irrespective of the cause. This hazard-agnostic approach works because the drivers are captured by the vulnerability components. For all cases, if an asset is no longer functioning, it will result in a major consequence.

The consequences assessment was conducted at a screening level to identify asset types whose vulnerabilities to climate change hazards could lead to significant consequences for the City. In future updates to this vulnerability assessment, the consequence assessment could be refined beyond the screening level by conducting consultations and more asset-specific analysis to score these consequences on an asset-specific scale.

Limitations

As mentioned earlier, the objective of Phase 1 of the vulnerability assessment was to screen all critical City assets to determine the types of assets and hazards that require further in-depth review. Due to data limitations and the hundreds of thousands of assets across many City departments, vulnerability scores were developed at the asset type level rather than for individual assets. The exposure of individual assets was analyzed, but the sensitivity and adaptive capacity of the assets were developed at the asset type level, and therefore the final vulnerability scores are also at the asset type level. The scores for sensitivity and adaptive capacity were based on a combination of literature review, expert knowledge, and department consultations. As such, the scores do not capture the nuanced and full range of vulnerability represented by each individual asset within the City.

The asset type vulnerability scores do not represent an average or summary of individual asset scores. They are meant to provide a relative understanding of the risk that selected climate change hazards could pose to the asset category.

The City does not present the findings in this report as a basis for policymaking or planning for individual assets. Instead, the vulnerability findings presented herein are meant to help the City identify which types of assets and hazards may warrant additional attention for further analysis and planning. Phase 2 of the

[21] Ecosystem services are services provided by nature that contribute to human and environmental well-being; they include provisioning services (e.g., providing food and water), regulating services (e.g., climate control and flood prevention), supporting services (e.g., nutrient cycling), and cultural services (e.g., recreation and heritage).

vulnerability assessment took a closer look at a representative sample of asset types that were found to warrant further attention.

Summary Vulnerability and Consequence Assessment Findings

This section summarizes the findings of the vulnerability assessment and consequence screens across sectors and climate change hazards. Detailed findings for each sector, organized by climate change hazard, are available in the sections below.

Vulnerability Assessment Findings

Based on the vulnerability assessment, which considered exposure, sensitivity, and adaptive capacity of each type of asset to each climate change hazard, the following critical asset types were determined to be the most vulnerable to climate change hazards:

- **Public safety:** lifeguard stations;
- **Water:** water pipes, wastewater pipes, water pump stations, wastewater pump stations;
- **Transportation and storm water:** bridges, major arterials, drain pump stations, outfalls;
- **Open space and environment:** conservation areas/open space/source water land, community parks, beaches;
- **Additional assets:** recreation centers; historical, tribal cultural, and archaeological resources.

The primary climate change hazard, based on the number of types of assets found to be vulnerable, was wildfire. Twenty–five (out of thirty-one total) asset types were found to have medium or high vulnerability to wildfire. This is due to an overall high sensitivity to fire, which has the potential to destroy assets in all sectors.

The results of the vulnerability assessment are presented in Table 11 below. “N/A” is used to indicate that the assets were not found to be exposed to the hazard, so sensitivity and adaptive capacity were not assessed, and the asset types were determined not to be vulnerable to the climate change hazard.

Cells that are shaded in green indicate asset types that may warrant further study and/or the development of adaptation strategies based on their vulnerability scores. All high vulnerability scores and some of the medium vulnerability scores are flagged in green. The flagged medium overall vulnerability scores are those that are composed of one high-scoring component (i.e., exposure, sensitivity, or adaptive capacity) and one medium score. This is essentially equivalent to a medium-high score rather than a medium-low score. In practical terms, this approach helps prioritize assets that are on the border between a high and medium, and thus are worthy of further study.

Table 11. Vulnerabilities of all Critical Asset Types to Climate Change Hazards[22]

Sector	Critical Asset	Coastal Flooding		Coastal Erosion	Precipitation-Based Flooding	Extreme Heat	Wildfire
		SLR[23]	Storm Surge with SLR[24]				
Public Safety Assets	Fire Stations	N/A	Low	N/A	Low	Low	Medium
	Lifeguard Stations	Medium	Medium	High	Medium	Low	Medium
	Fire Logistics and Dispatch	N/A	N/A	N/A	N/A	Low	N/A
	Maintenance Facilities	N/A	N/A	N/A	Medium	Low	Medium
	Police Stations	N/A	N/A	N/A	N/A	Low	High
	Police Patrol and Specialty Vehicles	N/A	N/A	N/A	Low	Low	Medium
	Other Public Safety	Medium	Medium	N/A	N/A	Low	Medium
Water Assets	Dams	N/A	N/A	N/A	High	Low	Medium
	Water Pipes	Medium	Medium	High	Medium	N/A	N/A
	Wastewater Pipes	Medium	Medium	High	Medium	N/A	N/A
	Water Pump Stations	N/A	N/A	N/A	Medium	Medium	High
	Wastewater Pump Stations	Low	Medium	High	High	Low	N/A
	Distribution Reservoirs	N/A	N/A	N/A	N/A	Medium	Medium
	Water Treatment Plants	N/A	N/A	N/A	N/A	Low	Medium
	Wastewater Treatment Plants	Low	Low	N/A	N/A	Medium	Medium
Transp	Airports	N/A	N/A	N/A	Low	Medium	High

[22] The vulnerability scores were calculated using a combination of spatial asset data provided by the City of San Diego or SanGIS, the best available spatial projections and localized modeling for the chosen climate hazard scenarios, and an assumption of asset type-level department consultations. The scores reported here do not reflect the vulnerability of specific, individual assets, but rather an assumption of asset type vulnerability. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

[23] Sea Level Rise (SLR) represents the area that is projected to experience daily flooding at average high tide under each sea level rise scenario.

[24] Storm surge with SLR represents the area that is projected to experience flooding due to the 100-year (1 percent annual chance) storm under each sea level rise scenario.

Sector	Critical Asset	Coastal Flooding		Coastal Erosion	Precipitation-Based Flooding	Extreme Heat	Wildfire
		SLR[23]	Storm Surge with SLR[24]				
	Bridges	High	Medium	High	Medium	Medium	High
	Major Arterials	High	Medium	Medium	Medium	Medium	High
	Drain Pump Stations	High	High	N/A	High	Low	High
	Outfalls	High	High	High	High	Medium	Medium
	Levees	Low	Low	N/A	Medium	Low	Medium
Open Space and	Conservation Areas/Open Space/Source Water Land	High	High	High	High	High	High
Open Space and	Community Parks	High	Medium	High	Medium	Medium	High
Open Space and	Miramar Landfill	N/A	N/A	N/A	N/A	Low	Medium
Open Space and	CNG Fueling Station	N/A	N/A	N/A	N/A	Low	Low
Open Space and	Beaches	High	Medium	High	Medium	Low	Medium
Additional Assets	Recreation centers	High	Low	N/A	Medium	Medium	Medium
Additional Assets	Libraries	N/A	N/A	N/A	N/A	Low	Medium
Additional Assets	City Buildings	N/A	N/A	N/A	N/A	Low	Medium
Additional Assets	Historical, Tribal Cultural, and Archaeological Resources	High	High	High	High	Medium	High

Consequences Assessment Findings

Damage, disruption, or failure of critical City assets could have major consequences that impede the City's ability to serve the community. Climate change impacts to these assets could compromise City services, such as emergency response, water treatment, or transportation; cause loss of life or injury; disproportionately impact communities of concern; damage historical, tribal cultural, and archaeological resources; or cause environmental damage. Assessing these consequences is important to understanding the significance of asset vulnerabilities.

The consequences for each sector (in bold) are described below.

- **Public Safety** – Many public safety assets are associated with key emergency services, such as fire stations and lifeguard stations, which face exposure to most or all hazards. If they are damaged, City services and human health could be affected. Delayed response times could increase the risk of loss of life or injury to people seeking emergency response, and facilities could be called to serve a larger area.
- **Water** – Impacts to wastewater systems could result in loss of the critical service of wastewater removal and treatment. Impacts to water systems could compromise access to clean water.

Consequences could include damages to human health and safety, social equity, and the environment.

- **Transportation** – Disruptions to transportation systems could delay or inhibit the movement of goods and people, which could reduce economic competitiveness and societal functioning. Emergency vehicles could also be delayed. The extent of damage will depend on the location and traffic load of the asset, and on the redundancy of the system.
- **Storm Water** – Damage to storm water infrastructure could exacerbate the impacts of flooding. Damage, disruption, or failure would primarily impact City services through responses to manage flood risk.
- **Open Space and the Environment** – If these assets are damaged, the City could lose resources that provide recreational opportunities, ecosystem services, and habitat value. There could be significant consequences to City services and natural resources and environment, in addition to some consequences to human health and social equity.
- **Additional Assets** – Libraries; City buildings; and historical, tribal cultural, and archaeological resources could also be damaged by climate-related hazards. Damages to these assets could have consequences to City services or directly to historical, tribal cultural, and archaeological resources. For example, libraries play an important role in community cohesion, and are used as cooling centers during periods of extreme heat.

Table 12 provides a summary of the types of consequences that could result from damage, disruption, or failure of each critical asset type. For each critical asset class/type, a check mark indicates that damage to the critical asset type could result in a consequence for that consequence category. Each section in the report below provides more details on the potential consequences of impacts to each sector, with illustrative examples of the types of consequences that could occur if critical assets are damaged.

Table 12. Summary of Consequences of Asset Types Being Damaged, Disrupted, or Failing due to Climate Hazards

Sector	Critical Asset	Consequence Categories				
		City Services	Human Health	Social Equity	Historical, Tribal Cultural, and Archaeological Resources	Natural Resources and Environment
Public Safety Assets	Fire Stations	✓	✓		✓	
	Lifeguard Stations	✓	✓		✓	
	Fire Logistics and Dispatch	✓	✓			
	Maintenance Facilities	✓				

Sector	Critical Asset	Consequence Categories				
		City Services	Human Health	Social Equity	Historical, Tribal Cultural, and Archaeological Resources	Natural Resources and Environment
	Police Stations[25]	✓	✓	✓	✓	
	Police Patrol and Specialty Vehicles	✓	✓			
	Other Public Safety	✓	✓			
Water Assets	Dams	✓	✓		✓	✓
	Water Pipes	✓	✓			
	Wastewater Pipes	✓	✓			
	Water Pump Stations	✓	✓			
	Wastewater Pump Stations	✓	✓			
	Distribution Reservoirs	✓	✓			
	Water Treatment Plants	✓	✓			
	Wastewater Treatment Plants	✓	✓			✓
Transportation and Storm Water Assets	Airports	✓	✓		✓	✓
	Bridges	✓	✓	✓	✓	
	Major Arterials	✓	✓	✓		
	Drain Pump Stations	✓	✓	✓		
	Outfalls	✓	✓			✓
	Levees	✓	✓			
Open Space and Environment Assets	Conservation Areas/Open Space/Source Water Land	✓	✓		✓	✓
	Community Parks		✓	✓	✓	✓
	Miramar Landfill	✓	✓			

[25] The "social equity" consequence for police stations refers to the Multicultural Storefront station. This is a Police building that is used constantly as a hub for citizens from other countries. It is a location for non-native-English speaking citizens to get services or directed to services, and for police to help with mediation of community groups.

Sector	Critical Asset	Consequence Categories				
		City Services	Human Health	Social Equity	Historical, Tribal Cultural, and Archaeological Resources	Natural Resources and Environment
	CNG Fueling Station	✓				
	Beaches	✓	✓	✓	✓	✓
Additional Assets	Recreation centers	✓	✓	✓	✓	
	Libraries	✓	✓	✓	✓	
	City buildings	✓			✓	
	Historical, Tribal Cultural, and Archaeological Resources				✓	

Public Safety Vulnerability Findings

Public safety assets include those under the Fire-Rescue and Police departments and the Office of Homeland Security. Within these departments, the following asset types are critical: fire stations, police stations, lifeguard stations, fire logistics and dispatch, maintenance facilities, police patrol and specialty vehicles, and other public safety assets (e.g., the Critical Incident Management Unit (CIMU) equipment location, police communications, evidence and property locations, and the emergency operations center). Not all assets in this list were found to be exposed to climate hazards.

The results of the vulnerability assessment for public safety are shown in Table 13. Assets that were not exposed to the climate change hazard are not vulnerable and therefore were not assessed for sensitivity and adaptive capacity.

The public safety critical asset type with the highest overall vulnerability is lifeguard stations, which face some level of exposure to all hazards and are highly vulnerable to coastal erosion.

Wildfire is the highest priority hazard, with all asset types aside from fire logistics and dispatch showing medium to high vulnerability.

Table 13. Vulnerability of Critical Public Safety Asset Types to Climate Change Hazards[26]

	SLR	Storm Surge with SLR	Coastal Erosion	Precipitation	Heat	Wildfire
Fire Stations	N/A	Low	N/A	Low	Low	Medium
Lifeguard Stations	Medium	Medium	High	Medium	Low	Medium
Fire Logistics and Dispatch	N/A	N/A	N/A	N/A	Low	N/A
Maintenance Facilities	N/A	N/A	N/A	Medium	Low	Medium
Police Stations	N/A	N/A	N/A	N/A	Low	High
Police Patrol and Specialty Vehicles	N/A	N/A	N/A	Low	Low	Medium
Other Public Safety	Medium	Medium	N/A	N/A	Low	Medium

Public Safety Consequences

Given the nature of public safety assets, their damage, disruption, or failure could result in significant consequences to City services and human health. Many of these assets are associated with key emergency services that would be affected. Delayed response of emergency services could increase risks and result in m potential injury or fatality. In addition, if some elements of the system are damaged or disrupted, other facilities may be called to serve a larger area.

Illustrative examples of the consequences of public safety asset damage, disruption, and failure are presented in Table 14. This table is provided purely to illustrate potential impacts; it is not meant to imply that these impacts will definitively occur, nor is this list fully comprehensive of all potential consequences to all asset types.

Table 14. Illustrative Consequences of Public Safety Asset Damage, Disruption, or Failure

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
Fire Stations	City Services Human Health	Fire services could be disrupted by climate-related hazards. If damages to a fire station were significant enough to warrant changes in operations or evacuation, response times could be extended if

[26] The vulnerability scores were calculated using a combination of spatial asset data provided by the City of San Diego or SanGIS, the best available spatial projections and localized modeling for the chosen climate hazard scenarios, and an assumption of asset type-level (general) of sensitivity and adaptive capacity based on literature reviews and high-level department consultations. The scores reported here do not reflect the vulnerability of specific, individual assets, but rather an assumption of asset type vulnerability. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
	Historical, Tribal Cultural, and Archaeological Resources	operational functionality was reduced or if fewer operable fire stations were able cover the area. If one fire station is closed, another may need to take calls from a wider radius. Wildfires may put pressure on firefighters and department resources if the frequency and intensity of fires increase (IRSST, 2013). La Jolla Fire Station Engine Company 14, Old Fire Station 14, Fire Station 4, and Fire Station 6 are City-owned designated historical resources. Additionally, other fire stations that are not currently designated may be eligible for designation pending evaluation. Damage to these buildings could impact their ability to convey historical and cultural information and value.
Lifeguard Stations	City Services Human Health Historical, Tribal Cultural, and Archaeological Resources	If stations became inoperable, the City's capacity to conduct safety patrols on the beaches could be reduced. This could put a greater number of people, particularly those engaging in water activities, at risk of drowning or injury. The San Diego Lifeguard Headquarters on Quivira Court is a City-owned building that may be eligible for designation as a historical resource. Additionally, other lifeguard stations that are not currently designated may be eligible for designation pending evaluation. Damage to these buildings could impact their ability to convey historical and cultural information and value. In addition, exposure to hazards such as heat could impact worker safety and lead to heat illness (Occupational Safety and Health Administration (OSHA), n.d.).
Fire Logistics and Dispatch	City Services Human Health	If the fire logistics and dispatch facilities are impacted by climate hazards, the ability of the Fire-Rescue Department to respond to emergency calls and send out resources could be compromised. Additionally, the logistics facility is used to provide storage and reserve apparatus that can be used if a fire station is compromised. Disruption in this service could impact the Department's ability to maintain full service and quick response times during an event.
Maintenance Facilities	City Services	Maintenance facilities help keep the Fire-Rescue Department fleet up and running. If these facilities were to be impacted by climate hazards, it could potentially slow down updates and repairs to fire and rescue vehicles. In addition, exposure to hazards such as heat could impact worker safety and lead to heat illness (Occupational Safety and Health Administration (OSHA), n.d.).

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
Police Stations	City Services Human Health Social Equity Historical, Tribal Cultural, and Archaeological Resources	Police stations and services could be disrupted by climate-related hazards. If police operations are compromised, response times to emergencies could be prolonged. The Multicultural Storefront is a City police station and functions as a key source of information for community members who are not native English speakers. Disruptions to this service and/or damage to this facility could disproportionately impact this population. Climate change hazards, such as wildfire, could be costly, requiring police officer overtime, traffic control, evacuation assistance, emergency operation centers and provision of food and water ($1.8 million for the October 2007 fires) (City of San Diego, 2007). The San Diego Police Pistol Range is a City-owned designated historical resource. Additionally, other police stations that are not currently designated may be eligible for designation pending evaluation. Damage to these buildings could impact their ability to convey historical and cultural information and value. In addition, exposure to hazards such as heat could impact worker safety and lead to heat illness (Occupational Safety and Health Administration (OSHA), n.d.).
Police Patrol and Specialty Vehicles	City Services Human Health	If police patrol and specialty vehicles were to be impacted by climate hazards, response times to emergencies could be compromised. Additionally, certain specialty vehicles serve a unique purpose (e.g., a decontamination bay; SWAT tactical vehicles) that have limited to no backup; disruption to these vehicles could limit the ability of the Police Department to pursue certain operations.
Other Public Safety	City Services Human Health	Other public safety assets include evidence and storage buildings, trailers, hangars, and the Critical Incident Management Unit (CIMU) Equipment Location. If these facilities were to be impacted by climate hazards, it could limit the ability of the Fire-Rescue and Police Departments to carry out their operations smoothly and quickly. In addition, exposure to hazards such as heat could impact worker safety and lead to heat illness (Occupational Safety and Health Administration (OSHA), n.d.).

Public Safety Vulnerability to Coastal Hazards

Coastal hazards include sea level rise, storm surge, and erosion. Daily flooding was used to estimate exposure to chronic inundation and represents the extent of flooding that would occur at high tide on average each day assuming each sea level rise scenario. Storm surge (100-year storm) flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm assuming each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

The City found that only three public safety critical asset types may be exposed to coastal hazards: fire stations, lifeguard stations, and other public safety assets. Lifeguard stations and other public safety assets are vulnerable to chronic flooding through sea level rise, all three are vulnerable to periodic flooding through storm surge with sea level rise, and lifeguard stations are vulnerable to erosion. All erosion scenarios assume 2.0 meters of sea level rise by 2100 (which is the upper range for 2100).

The results of the vulnerability assessment of critical public safety asset types to sea level rise, storm surge with sea level rise, and coastal erosion are shown in Table 15, Table 16, and Table 17, respectively. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to coastal hazards. Table 18 provides the rationale for the sensitivity and adaptive capacity scores.

Table 15. Vulnerability of City of San Diego Public Safety Critical Asset Types to Sea Level Rise

SLR	Fire Stations	Lifeguard Stations	Fire Logistics and Dispatch	Maintenance Facilities	Police Stations	Police Patrol and Specialty Vehicles	Other Public Safety
Exposure	Not exposed	High	Not exposed	Not exposed	Not exposed	Not exposed	Low
Sensitivity	N/A	Medium	N/A	N/A	N/A	N/A	High
Adaptive Capacity	N/A	Medium	N/A	N/A	N/A	N/A	Medium
Vulnerability	**N/A**	Medium	**N/A**	**N/A**	**N/A**	**N/A**	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 16. Vulnerability of City of San Diego Public Safety Critical Asset Types to Storm Surge with Sea Level Rise (One Hundred-Year storm)

Storm Surge with SLR	Fire Stations	Lifeguard Stations	Fire Logistics and Dispatch	Maintenance Facilities	Police Stations	Police Patrol and Specialty Vehicles	Other Public Safety
Exposure	Low	High	Not exposed	Not exposed	Not exposed	Not exposed	Low
Sensitivity	Medium	Low	N/A	N/A	N/A	N/A	High
Adaptive Capacity	Medium	High	N/A	N/A	N/A	N/A	Medium
Vulnerability	Low	Medium	**N/A**	**N/A**	**N/A**	**N/A**	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City *department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.*

Table 17. Vulnerability of City of San Diego Public Safety Critical Asset Types to Coastal Erosion at Medium-High Risk Aversion Scenario of 2m of Sea Level Rise

Coastal Erosion	Fire Stations	Lifeguard Stations	Fire Logistics and Dispatch	Maintenance Facilities	Police Stations	Police Patrol and Specialty Vehicles	Other Public Safety
Exposure	Not exposed	High	Not exposed	Not exposed	Not exposed	Not exposed	Not exposed
Sensitivity	N/A	High	N/A	N/A	N/A	N/A	N/A
Adaptive Capacity	N/A	Medium	N/A	N/A	N/A	N/A	N/A
Vulnerability	**N/A**	**High**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Public Safety Exposure to Coastal Hazards

Most public safety assets are not exposed to sea level rise, as shown in Figure 10. However, lifeguard stations and other public safety assets may face exposure to inundation from sea level rise.

Figure 11 shows that more public safety assets may be exposed to storm surge with sea level rise than are projected to be exposed to sea level rise alone. Ten percent of permanent lifeguard stations could be exposed to storm surge with sea level rise starting at 0.25 meters (2030), and twenty to forty percent of these stations may be exposed by 2100. Storm surge with sea level rise also brings some fire stations into the inundation zone: at 2.0 meters of sea level rise, two fire stations may be exposed to storm surge with sea level rise. Other public safety assets face exposure to storm surge starting at 0.75 meters of sea level rise (approximately 2050).

> **Sea Level Rise Projections for San Diego**
>
> 2030: 0.25 m
>
> 2050: 0.5 to 0.75 m
>
> 2100: 1.0 to 2.0 m

As Figure 12 shows, only lifeguard stations face exposure to cliff erosion. Thirty percent of permanent lifeguard stations may be affected if cliffs erode.

Figure 13 shows that only lifeguard stations could be exposed to beach erosion. Lifeguard stations may be more exposed to beach erosion than to cliff erosion, with forty percent of stations facing exposure.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the coastal hazard scenarios.

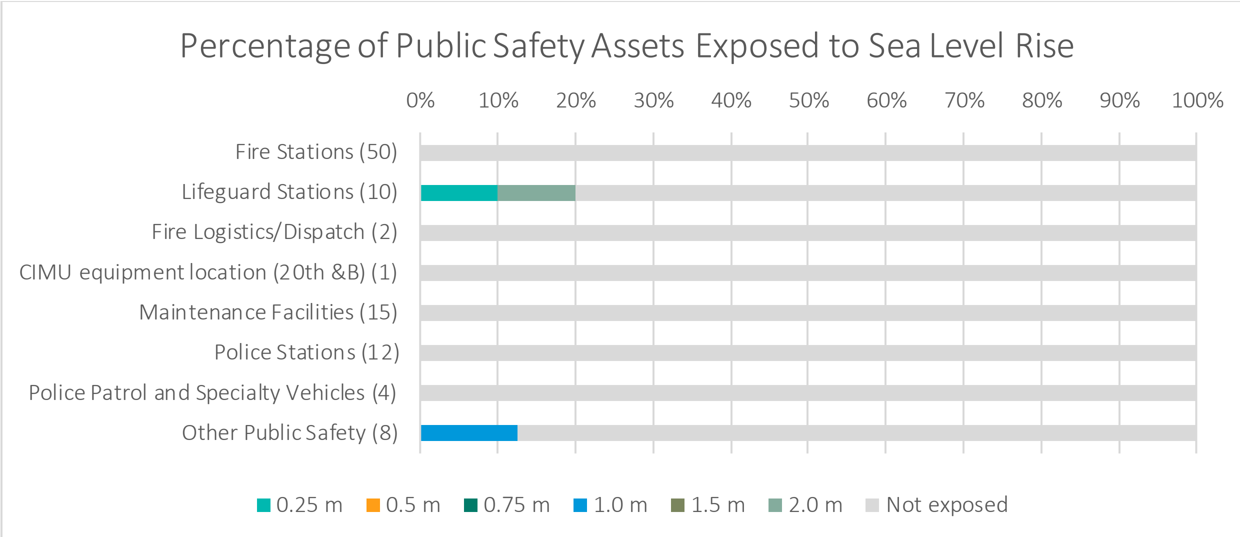

Figure 10. Public safety critical assets exposed to sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario.

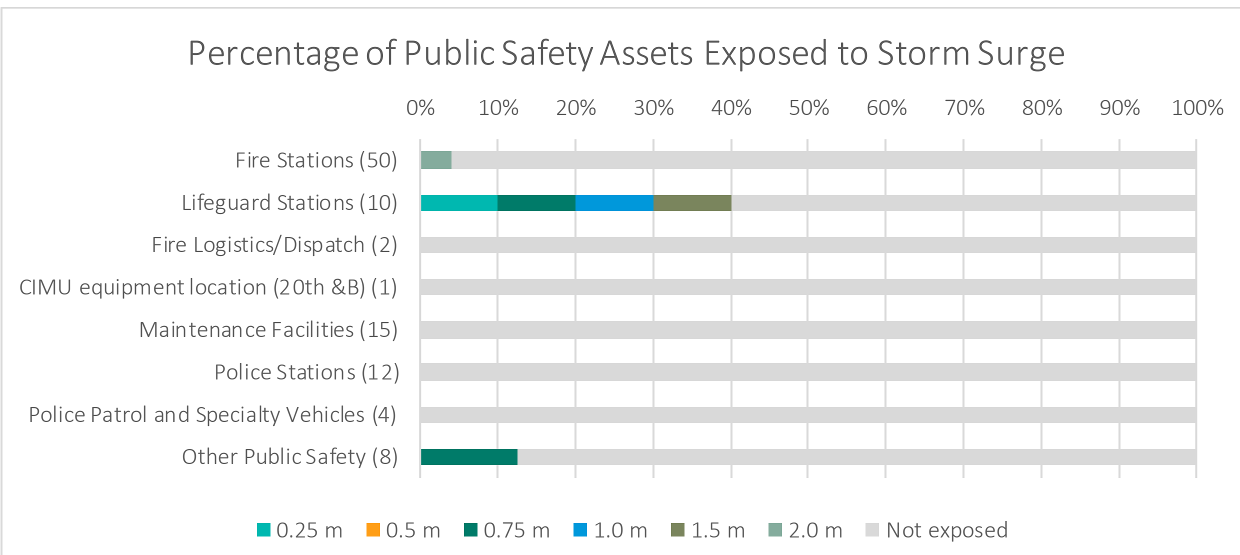

Figure 11. Public safety critical assets exposed to sea level rise + 100-year storm surge. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario. Assets would be exposed to storm surge prior to being exposed to average flooding, so more assets in this graph tend to be exposed under lower sea level rise amounts.

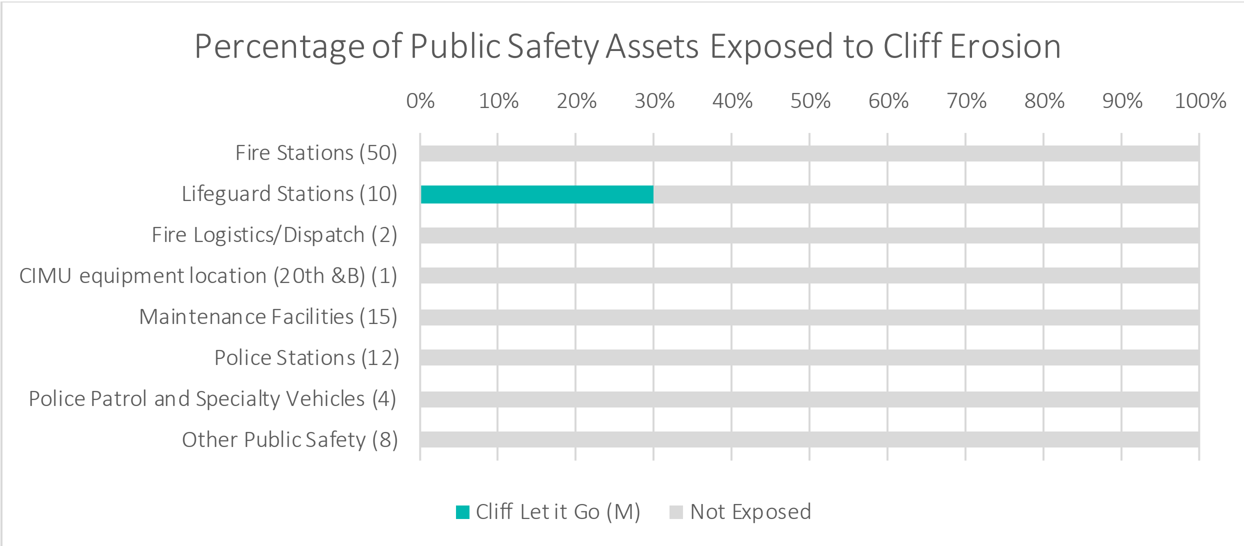

Figure 12. Public safety critical assets exposed to cliff erosion. The value after each asset name indicates the asset count. "Cliff let it go" represents the number of assets exposed to flooding if the City does not implement coastal armoring and allows cliff retreat and erosion.

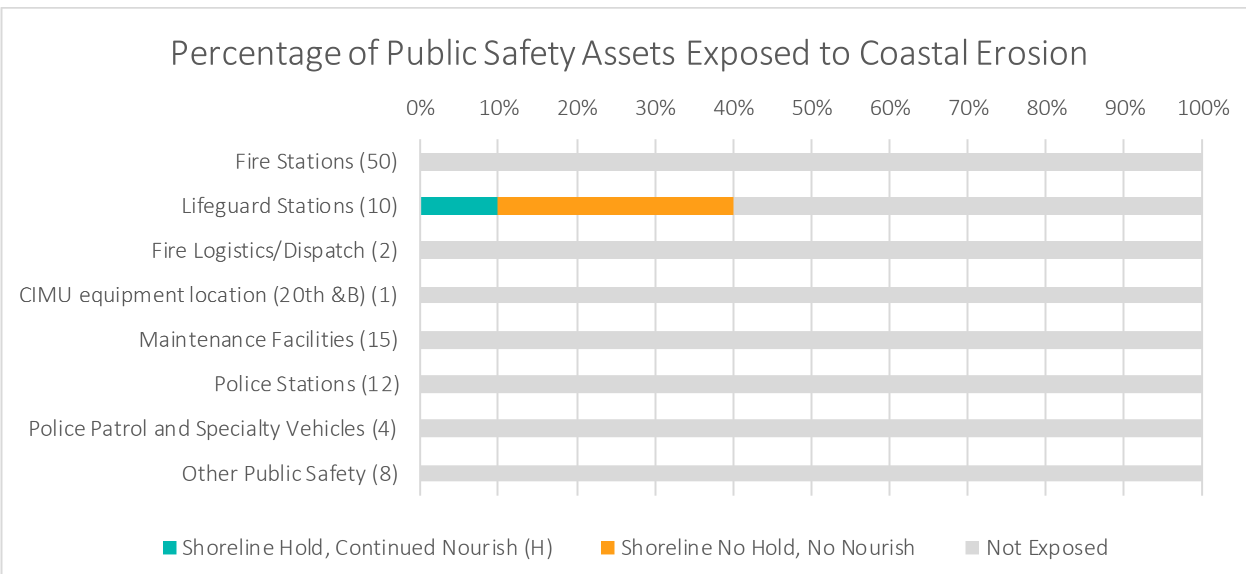

Figure 13. Public safety critical assets exposed to beach erosion. The value after each asset name indicates the asset count. "Shoreline Hold, Continued Nourish" represents the number of assets exposed to flooding if the City continues beach nourishment and sea wall repair, while "Shoreline No Hold, No Nourish" represents the number of assets exposed if the City were to stop beach nourishment and seawall repair.

Public Safety Sensitivity and Adaptive Capacity to Coastal Hazards

Based on the exposure analysis, fire stations, lifeguard stations, and other public safety assets were included in the sensitivity and adaptive capacity analysis. The ratings and corresponding rationale for these asset types are shown in Table 18.

Table 18. Sensitivity and Adaptive Capacity of Public Safety Critical Asset Types Exposed to Coastal Hazards

Fire Stations	
SLR Sensitivity: Not exposed	*SLR Adaptive Capacity: Not exposed*
Storm Surge with SLR Sensitivity: Medium Exposure of fire stations to storm flooding events could increase wear and tear on buildings. Storm-induced flooding could temporarily limit access to and use of a station (USAID, 2014).	*Storm Surge with SLR Adaptive Capacity: Medium* Short-term solutions exist for flood protection (e.g., sandbags); longer-term adaptation is more difficult and costly. Affected stations can operate remotely if necessary, and the Fire-Rescue department has a Ready Reserve Fleet with thirty-two fully equipped fire engines that are ready for use if a weather event puts other engines out of commission.
Erosion Sensitivity: Not exposed	*Erosion Adaptive Capacity: Not exposed*
Lifeguard Stations	
SLR Sensitivity: Medium Sea level rise could permanently inundate buildings within the projected sea level rise zone, could increase the erosion of structures, and could damage or destroy buildings and equipment (USAID 2014). Sensitivity varies across lifeguard stations: newer stations have been designed to accommodate sea level rise, but older stations have not.	*SLR Adaptive Capacity: Medium* Short term solutions exist for flood protection (e.g., opening doors to allow water to flow through and out), but longer-term adaptation for chronic flooding is more difficult. Lifeguard stations are reconstructed approximately every thirty years, and all new designs now account for sea level rise.
Storm Surge with SLR Sensitivity: Low Sensitivity varies across lifeguard stations: newer stations have been designed to accommodate sea level rise, but older stations have not. In addition to the permanent stations considered in this assessment, San Diego has seasonal mobile towers that could easily be brought back into service after experiencing flooding, assuming they do not wash away.	*Storm Surge with SLR Adaptive Capacity: High* Lifeguard stations are reconstructed approximately every thirty years. The City has plans to build new stations to accommodate storm-based inundation (by locating all facilities on the second floor). In most existing towers, equipment could be relocated to the second floor to avoid exposure to periodic ground-level flooding (Consultation with City of San Diego Fire-Rescue Department, 2019). In addition, in the event of temporary flooding, mobile lifeguard stations and other lifeguard stations could serve as a backup resource.
Coastal Erosion Sensitivity: High If coastal erosion were to threaten the building structure of a permanent lifeguard station, the facility would need to be moved.	*Coastal Erosion Adaptive Capacity: Medium* Mobile lifeguard towers could be moved to safer locations; however, permanent lifeguard stations cannot easily be moved, and it is recognized that

	the lifeguard stations need to be located immediately adjacent to the coast. At some stations, there are some concrete erosion barriers that have been built to better protect stations against coastal erosion.
Other Public Safety	
SLR Sensitivity: High The Police Department's evidence and property building is highly sensitive to flooding (Consultation with City of San Diego Police Department, 2019). Sea level rise could permanently inundate buildings within the projected sea level rise zone, could increase the erosion of structures, and could damage or destroy buildings and equipment (USAID 2014).	*SLR Adaptive Capacity: Medium* Longer-term adaptation may be necessary if chronic flooding within the coastal zone becomes a highly likely scenario (Consultation with City of San Diego Police Department, 2019).
Storm Surge with SLR Sensitivity: High The Police Department's evidence and property building is highly sensitive to flooding (Consultation with City of San Diego Police Department, 2019).	*Storm Surge with SLR Adaptive Capacity: Medium* Short-term solutions exist for flood protection (e.g., sandbags), but longer-term adaptation is more difficult and costly (Consultation with City of San Diego Police Department, 2019).
Coastal Erosion Sensitivity: Not exposed	*Coastal Erosion Adaptive Capacity: Not exposed*

Public Safety Vulnerability to Precipitation-driven Flooding

The City found that public safety critical asset types have near-negligible vulnerability to precipitation-driven flooding. Fire stations and police patrol and specialty vehicles have low vulnerability to precipitation-driven flooding. These asset types have low exposure, meaning that none of them are located within the 100-year floodplain. Fire stations, lifeguard stations, and police patrol and specialty vehicles show low to medium sensitivity, as exposure to precipitation-driven flooding could result in temporary damage that requires repair but would not require a complete replacement of the asset. Lifeguard stations and police patrol and specialty vehicles have high adaptive capacity due to current and planned measures to protect these assets against precipitation-driven flooding. Maintenance facilities show medium sensitivity and high adaptive capacity but are rated as medium vulnerability due to their location within the 100-year floodplain, giving them a high exposure score.

The results of the vulnerability assessment of critical public safety asset types to precipitation-driven flooding are shown in Table 19. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to precipitation-driven flooding. Table 20 provides the rationale for the sensitivity and adaptive capacity scores.

Table 19. Vulnerability of Public Safety Critical Asset Types to Precipitation-driven Flooding

	Fire Stations	Lifeguard Stations	Fire Logistics and Dispatch	Maintenance Facilities	Police Stations	Police Patrol and Specialty Vehicles	Other Public Safety
Exposure	Low	High	Not exposed	High	Not exposed	Low	Not exposed
Sensitivity	Medium	Low	N/A	Medium	N/A	Medium	N/A
Adaptive Capacity	High	High	N/A	Medium	N/A	High	N/A
Vulnerability	Low	Medium	N/A	Medium	N/A	Low	N/A

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Public Safety Exposure to Precipitation-Driven Flooding

Figure 14 shows critical public safety asset types that may face exposure to precipitation-driven flooding. Fire stations, lifeguard stations, maintenance facilities, and police patrol and specialty vehicles parking lots all face some exposure to heavy precipitation-driven flooding risks (that is, exposure to the 100- and/or 500-year floodplains). Only a few public safety assets face exposure to precipitation-driven hazards: in total, four assets lie in the 500-year floodplain and two face exposure to the 100-year floodplain.

The only public safety assets that lie in the 100-year floodplain are a permanent lifeguard station and a maintenance facility. One fire station, one lifeguard station, one maintenance facility, and a police patrol and specialty vehicle lot lie in the 500-year floodplain. However, because there are only four police patrol and specialty vehicle parking lots in the City, this puts a high proportion of that asset type at risk.

Additionally, many command vehicles are kept at 20th and B, which has flooded in the past, but was not shown to be exposed to the FEMA 100- or 500-year floodplains.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to precipitation-driven flooding.

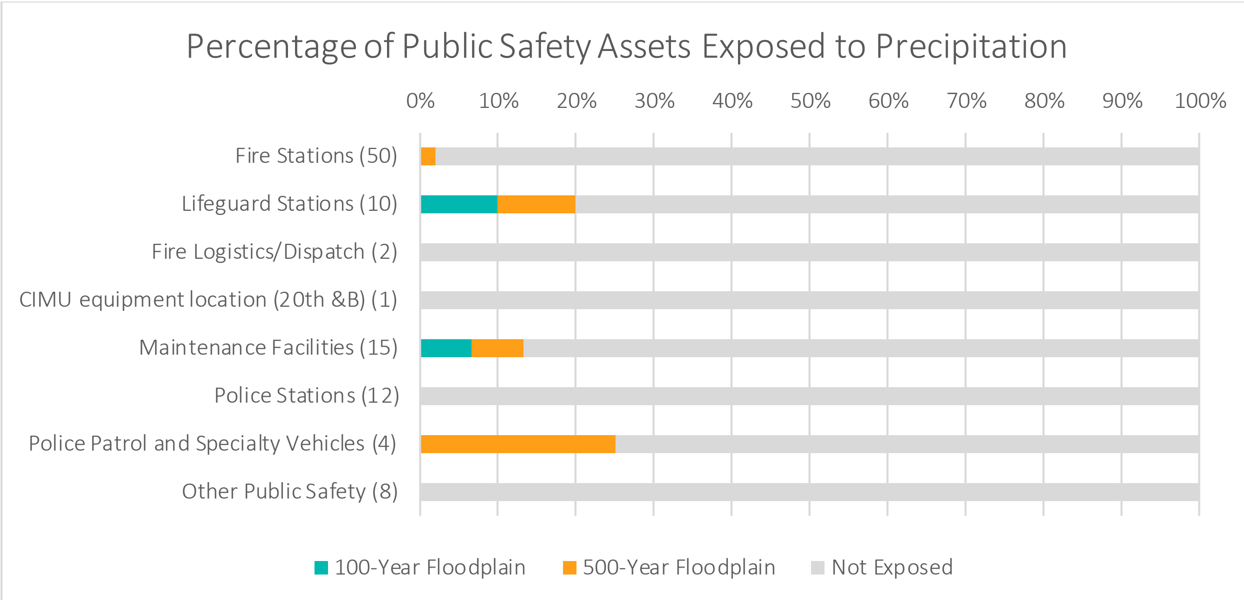

Figure 14. Public Safety critical assets exposed to precipitation. The value after each asset name indicates the asset count. All assets in the 100-year floodplain also lie in the 500-year floodplain; the orange colored bar for the 500-year floodplain shows assets that are outside the 100-year floodplain but experience flooding under more extreme precipitation events.

Public Safety Sensitivity and Adaptive Capacity to Precipitation-driven Flooding

Based on the exposure assessment, the City reviewed sensitivity and adaptive capacity for fire stations, lifeguard stations, maintenance facilities, and police patrol and specialty vehicles. The results of this assessment are shown in Table 20.

Table 20. Sensitivity and Adaptive Capacity of Public Safety Critical Asset Types to Precipitation-driven Flooding

Fire Stations	
Precipitation Sensitivity Rating: Medium Previous precipitation events have caused water leaks and damage. The greatest damage occurs when rainwater gets into drywall (Consultation with City of San Diego Police Department, 2019).	*Precipitation Adaptive Capacity Rating: High* Responding to damage caused by water leaks is relatively inexpensive; previous events have caused damage ranging from $500 to $7,500 per repair project (City of San Diego, 2017b; City of San Diego, 2017c). Protective measures include building berms and setting up sandbags. However, limitations to access in or out of the fire station could be posed by floodwater or the berms or sandbags themselves. Infrastructure critical to functioning (e.g., fire engines) must be kept on the ground floor, however the fire department is able to move equipment (e.g., fire engines) to another station and dispatch from a different location if necessary during a storm event.

	Affected stations can operate remotely if necessary, and the Fire-Rescue department has a Ready Reserve Fleet with thirty-two fully equipped fire engines that are ready for use if a weather event puts other engines out of commission.
Lifeguard Stations	
Precipitation Sensitivity Rating: Low Mobile towers could easily be brought back into service after experiencing flooding, assuming they do not wash away.	*Precipitation Adaptive Capacity Rating: High* The City has plans to build new stations to accommodate inundation (by locating all facilities on the second floor). In existing towers, equipment will be relocated to the second floor (Consultation with City of San Diego Fire-Rescue Department, 2018). Mobile lifeguard towers could be moved to safer locations; however, permanent lifeguard stations do not have such flexibility. Short-term solutions exist for temporary flood protection (e.g., opening doors to allow water to flow through and out). In addition, in the event of temporary flooding, mobile lifeguard stations and other lifeguard stations could serve as a backup resource.
Maintenance Facilities	
Precipitation Sensitivity Rating: Medium Only one facility (Chollas) has previously experienced water damage from flooding. This damage included rot to the wood entry door, time taken to squeegee out water before and during shifts and shutting down the paint booth and body/welding repairs in three bays due to standing water. Significant flooding has the potential to negate the ability to maintain and fuel vehicles (Consultation with City of San Diego Fleet Operations, 2019).	*Precipitation Adaptive Capacity Rating: Medium* Sandbags are deployed when necessary to protect against flood damages, and most facilities have adequate drainage to handle heavy rain events. Drainage could be improved at the one station (Chollas) that has previously experienced water damage (Consultation with City of San Diego Fleet Operations, 2019).
Police Patrol and Specialty Vehicles	
Precipitation Sensitivity Rating: Medium Heavy rain events pose the risk of engine inundation, which could lead to engine stall and/or damage. Flooding on roads could decrease visibility and increase risk of hydroplaning and accidents (NIST, 2006). Vehicle replacement cost could be high (Consultation with City of San Diego Police	*Precipitation Adaptive Capacity Rating: High* Vehicles not in use could be temporarily relocated if necessary; this is already standard practice in the City. However, a standard number must remain in all areas for emergency response (Consultation with City of San Diego Fleet Operations, 2018).

Department, 2018).	

Public Safety Vulnerability to Heat

The City found that all public safety critical asset types are vulnerable to heat, because all face some level of exposure. However, all public safety asset types were found to have low vulnerability to heat. See Figure 8 for a map of urban heat island zones in the City. The zones are scored from 0 to 100+, with lower scores denoting less heat (these are usually coastal areas, with high heat areas farther inland).

The results of the vulnerability assessment of public safety asset types to heat are shown in Table 21. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to heat. Table 22 provides the rationale for the sensitivity and adaptive capacity scores.

Table 21. Vulnerability of Public Safety Critical Asset Types to Heat

	Fire Stations	Lifeguard Stations	Fire Logistics and Dispatch	Maintenance Facilities	Police Stations	Police Patrol and Specialty Vehicles	Other Public Safety
Exposure	Medium	Low	Medium	Medium	Medium	Medium	Medium
Sensitivity	Low	Low	Low	Low	Low	Low	Low
Adaptive Capacity	High	Medium	Medium	High	High	High	High
Vulnerability	Low	Low	Low	Low	Low	Low	Low

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10.

Public Safety Exposure to Heat

The heat island scenarios are represented as zones with scores of 0 to 100+, with higher scores denoting hotter areas (CalEPA, 2019).[27] A score of zero indicates that there is no difference in temperature over time between an urban Census tract and nearby upwind rural

In San Diego, coastal areas are relatively cooler than inland areas due to the moderating impacts of the ocean and offshore winds. This coastal effect dominates the urban heat island effect in the City.

[27] The urban heat island index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period. To estimate the total number of degrees Fahrenheit per day, divide the Index by 24 hours and multiply by 1.8 degrees. Higher scores denote hotter areas.

reference points. A score of 100 indicates that there is a difference of 7.5 degrees Fahrenheit (approx. 4.2 degrees Celsius) between these tracts over 24 hours.

Public safety assets have varying degrees of exposure to high temperatures (Figure 15). Almost all of these exposures are in the 0 to 20, 20 to 40, and 40 to 60 UHI zone ranges; only six public safety assets face heat exposure in the 60 to 80 range.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the heat levels.

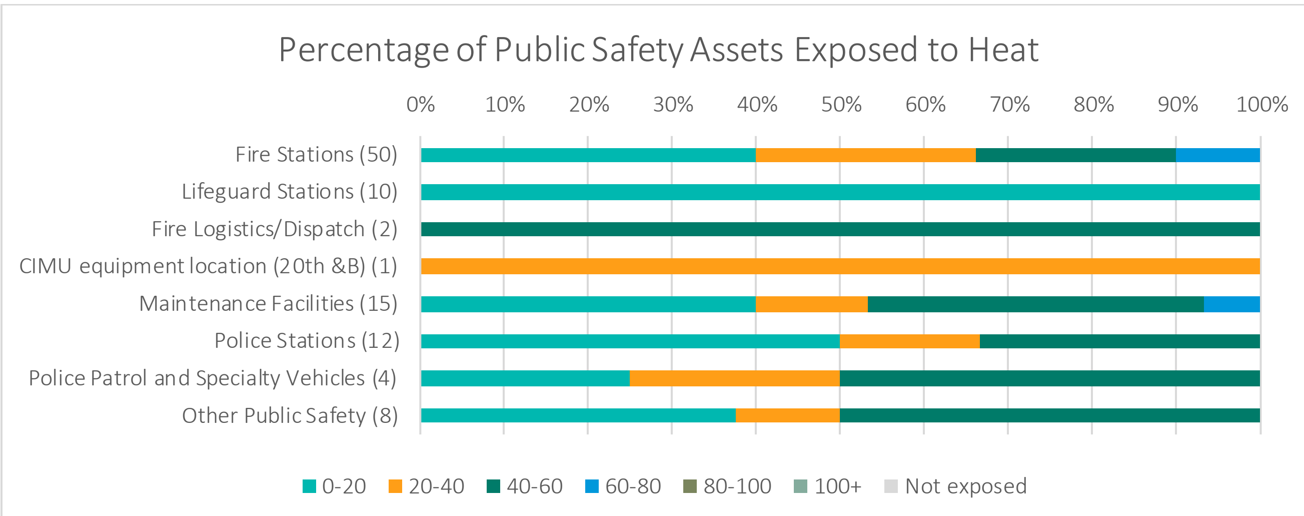

Figure 15. Public safety critical assets exposed to heat. The value after each asset name indicates the asset count. The colored bars represent exposure to different ranges in the UHI index, with higher UHI values denoting hotter areas and therefore increased exposure to heat.

Public Safety Sensitivity and Adaptive Capacity to Heat

Based on the exposure analysis, the City reviewed the sensitivity and adaptive capacity of all public safety critical asset types to heat. The results of this analysis are shown in Table 22 below.

Table 22. Sensitivity and Adaptive Capacity of Public Safety Critical Asset Types to Heat

Fire Stations	
Heat Sensitivity Rating: Low	*Heat Adaptive Capacity Rating:* High
Thermal stress could cause wear on building materials and place an increased load on mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011).	All fire stations have air conditioning to help maintain a safe work environment during high heat, but not all systems are energy efficient (Consultation with City of San Diego Fire-Rescue Department, 2019).
Lifeguard Stations	
Heat Sensitivity Rating: Low	*Heat Adaptive Capacity Rating:* Medium
Thermal stress could cause wear on building materials and place an increased load on	Not all lifeguard stations have air conditioning, and not all electric equipment at stations is

mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011).	energy efficient. Equipment is upgraded to energy efficient versions when it is replaced (Consultation with City of San Diego Fire-Rescue Department, 2019).
Fire Logistics and Dispatch	
Heat Sensitivity Rating: *Low* Thermal stress could cause wear on building materials and place an increased load on mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011)	*Heat Adaptive Capacity Rating:* *Medium* New buildings (built within the last five to eight years) are guaranteed to be energy efficient. New City design standards require all buildings to either be LEED certified or energy efficient. All buildings built before this standard would likely not be energy efficient (City of San Diego Facilities, 2019).
Maintenance Facilities	
Heat Sensitivity Rating: *Low* Thermal stress could cause wear on building materials and place an increased load on mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011).	*Heat Adaptive Capacity Rating:* *High* Two types of facilities have designated spaces with air conditioning (police repair and fire repair); the Rose Canyon and Chollas facilities have no air conditioning. Newer facilities have energy efficient equipment, and older facilities upgrade to energy efficient equipment as the older equipment fails (Consultation with City of San Diego Fleet Operations, 2019).
Police Stations	
Heat Sensitivity Rating: *Low* Thermal stress could cause wear on building materials and place an increased load on mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011).	*Heat Adaptive Capacity Rating:* *High* The heat-related policy for the Police Department could be easily updated to consider current and future needs for water, cover, and relief associated with future heat conditions (Consultation with City of San Diego Police Department, 2019).
Police Patrol and Specialty Vehicles	
Heat Sensitivity Rating: *Low* Vehicles may overheat on high heat days, which may cause damage to engine components (OFCM, 2002). Additionally, worker safety risk and the chance of accidents increase under high heat conditions (Koetse & Rietveld, 2009; OFCM, 2002; Stern & Zehavi, 1990).	*Heat Adaptive Capacity Rating:* *High* In the event that those vehicles in operation become overheated, the San Diego Police Department, CIMU, Parking Enforcement Unit, and Air Support Unit all have backup vehicles (Consultation with City of San Diego Police Department, 2019).
Other Public Safety	

Heat Sensitivity Rating: Low	*Heat Adaptive Capacity Rating: High*
Thermal stress could cause wear on building materials and place an increased load on mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011).	All other fire public safety assets [CIMU Equipment Location (19th and B), DRC basement emergency operations] have air conditioning, but not all systems are energy efficient (Consultation with City of San Diego Fire-Rescue Department, 2019). Some, but not all, other police safety assets have air conditioning, some of these assets are energy efficient (Consultation with City of San Diego Fleet Operations, 2019).

Public Safety Vulnerability to Wildfires

The City found that nearly all critical public safety asset types face high exposure to wildfires. Only fire logistics and dispatch facilities were found to be wholly outside of the fire hazard zone and therefore not vulnerable.

Fire stations and police stations were the only asset types with assets located within 100 feet of the City's brush management zone, which indicates high potential exposure to wildfire. Lifeguard stations, maintenance facilities, police patrol and specialty vehicles, and the CIMU equipment location at 20th and B (which is considered one of the "other public safety" assets) all have assets within 300 feet of the City's brush management zone, indicating medium potential exposure to wildfire. All of these asset types have high sensitivity to wildfire, as exposure could potentially damage them beyond repair or destroy the asset.

The results of the vulnerability assessment of public safety asset types to wildfire are shown in Table 23. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to wildfire. Table 24 provides the rationale for the sensitivity and adaptive capacity scores.

Table 23. Vulnerability of Public Safety Critical Asset Types to Wildfire

	Fire Stations	Lifeguard Stations	Fire Logistics and Dispatch	Maintenance Facilities	Police Stations	Police Patrol and Specialty Vehicles	Other Public Safety
Exposure	High	Medium	Not exposed	Medium	High	Medium	Medium
Sensitivity	Medium	High	N/A	High	High	High	High
Adaptive Capacity	High	Medium	N/A	High	Medium	High	Medium
Vulnerability	Medium	Medium	N/A	Medium	High	Medium	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Public Safety Exposure to Wildfires

Wildfire Hazard Zones for San Diego

High: Native vegetation and 100-foot setback zones

Medium: 300-foot setback zone

Low: Fire hazard zone outside native vegetation zone and setbacks

Of public safety assets, only one type—fire logistics and dispatch facilities—has no assets within the wildfire hazard zones (Figure 16).

The remaining six asset types vary greatly in their exposure to wildfires, though none have a majority of their assets facing potential wildfire exposure. Lifeguard stations, maintenance facilities, police patrol and specialty vehicles, and other public safety assets have most exposed assets facing medium exposure to wildfire. Only four fire stations and one police station potentially face high exposure to wildfire.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the fire hazard zones.

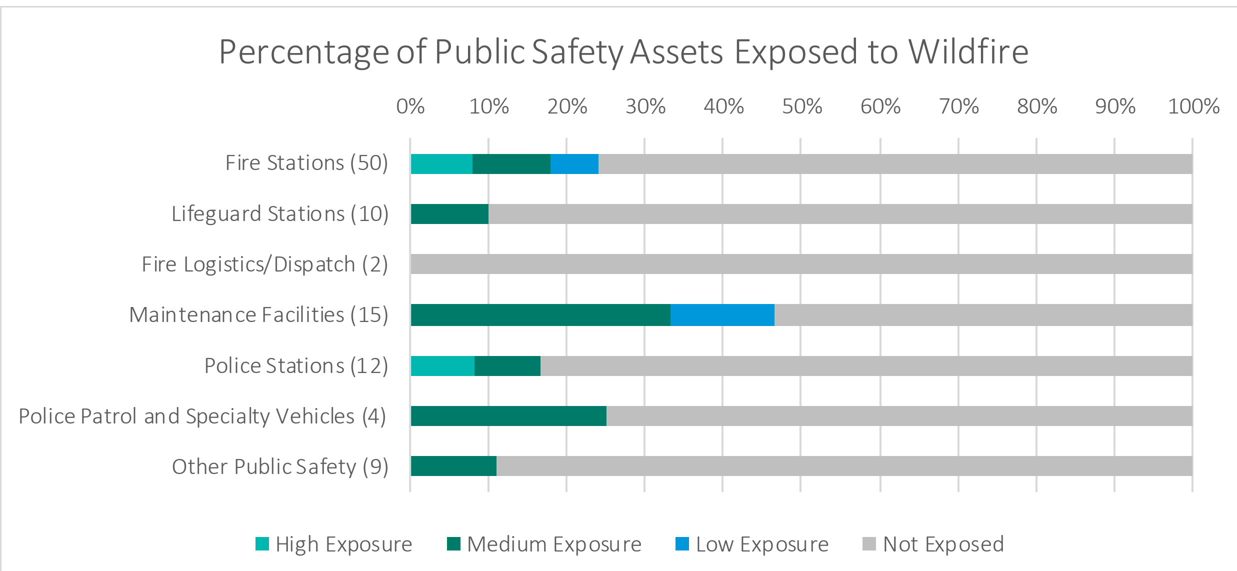

Figure 16. Public safety critical assets exposed to wildfire. The value after each asset name indicates the asset count.

Public Safety Sensitivity and Adaptive Capacity to Wildfires

Based on the exposure assessment, the City assessed the sensitivity and adaptive capacity of all critical public safety asset types (except fire logistics and dispatch facilities) and other public safety assets to wildfire. The findings of this assessment are shown in Table 24 below.

Table 24. Sensitivity and Adaptive Capacity of Public Safety Critical Asset Types to Wildfire

Fire Stations	
Wildfire Sensitivity Rating: Medium	*Wildfire Adaptive Capacity Rating: High*
Wildfires could directly damage buildings and could accelerate building material deterioration	In the event of a fire station fire, there are backup personnel and equipment within the City to

due to increased smoke and particulate matter (USAID, 2014). Several fire stations have a wood frame covered with stucco and one station has wood siding. Heating Ventilation and Air Conditioning (HVAC) filters at the stations are changed at least once a year. Of the total forty-nine fire stations, thirteen of the new stations have fire suppression systems and sprinklers installed. Newer facilities are built to a more fire-resistant standard and use building materials such as concrete block walls and aluminum frames.	respond and maintain service. The San Diego Fire-Rescue has forty-nine fire stations that are staffed 24/7/365. Affected stations can operate remotely if necessary, and the Fire-Rescue department has a Ready Reserve Fleet with thirty-two fully equipped fire engines that are ready for use if a weather event puts other engines out of commission. In addition, the fire department is able to move apparatus and personnel to an alternate station in the event that the original station is threatened by fire (Consultation with City of San Diego Fire-Rescue Department, 2019).
Lifeguard Stations	
Wildfire Sensitivity Rating: High Wildfires could directly damage buildings and could accelerate building material deterioration due to increased smoke and particulate matter (USAID, 2014).	*Wildfire Adaptive Capacity Rating: Medium* All buildings have fire extinguishers in compliance with OSHA and public building safety practices, and newer stations have adequate air system filters and fire suppression systems (Consultation with City of San Diego Fire-Rescue Department, 2019).
Maintenance Facilities	
Wildfire Sensitivity Rating: High Wildfires could directly damage buildings and could accelerate building material deterioration due to increased smoke and particulate matter (USAID, 2014). The main fire repair facility at Miramar does not have any wooden construction. The Rose Canyon and Chollas facilities are built with cement walls and a wood roof structure (Consultation with City of San Diego Fleet Operations, 2019).	*Wildfire Adaptive Capacity Rating: High* All police and fire repair facilities have fire suppression systems. The Rose Canyon facility has a sprinkler system and fire extinguishers throughout the building. The Chollas facility has fire extinguishers throughout the building but the sprinkler system is only in the paint booth (Consultation with City of San Diego Fire-Rescue Department, 2019).
Police Stations	
Wildfire Sensitivity Rating: High Wildfires could directly damage buildings and could accelerate building material deterioration due to increased smoke and particulate matter (USAID, 2014).	*Wildfire Adaptive Capacity Rating: Medium* The Police Department currently has a backup dispatch communications center with limited functional capacity. If one station were to be compromised due to wildfire, those personnel and vehicles would be dispatched to or stored at one of the other eleven police stations (Consultation with City of San Diego Police Department, 2019).
Police Patrol and Specialty Vehicles	

Wildfire Sensitivity Rating: High	*Wildfire Adaptive Capacity Rating: High*
Wildfires could directly damage vehicles. Smoke and particulates could cause dangerously low visibility (Peterson, McGuirk, Houston, Horvitz, & Wehner, 2008).	Backup patrol and specialty vehicles are maintained at police stations, police headquarters, San Diego Police Plaza, and Central Garage, which are within the area potentially exposed to fire. However, vehicles could be moved if necessary to areas not threatened by fire.
Other Public Safety	
Wildfire Sensitivity Rating: High	*Wildfire Adaptive Capacity Rating: Medium*
Wildfires could directly damage buildings and could accelerate building material deterioration due to increased smoke and particulate matter (USAID, 2014). Of the other police assets, the Air Support Unit hangar, twelve out of fourteen property and evidence facilities, and the buildings at 20th and B are made of fire-susceptible materials (Consultation with City of San Diego Fire-Rescue Department, 2019).	Some, but not all, have air filters or fire suppression systems that include sprinklers (Consultation with City of San Diego Police Department, 2019).

Water Assets Vulnerability Findings

Water infrastructure assets include those managed by the Public Utilities Department (PUD). The following asset types are considered to be critical: dams, water pipes, wastewater pipes, water pump stations, wastewater pump stations, distribution reservoirs, water treatment plants, and wastewater treatment plants. “Water pipes” refers to transmission and distribution mains. Not all assets in this list were found to be exposed to climate hazards. In order to focus the assessments on the most critical assets, “wastewater pump stations” includes the eight largest and most important wastewater pump stations, not all City wastewater pump stations.

Separately, PUD owns and manages open space land that serves the primary purpose of capturing and protecting native source water. This land is included under the “Conservation Areas/Open Space/Source Water Land” asset type in the Open Space and Environment Vulnerability Findings section of this report.

The results of the vulnerability assessment for water infrastructure are shown in Table 25. “N/A” indicates that the assets were not found to be exposed to the hazard, so sensitivity and adaptive capacity were not assessed, and the asset types were deemed not vulnerable.

Generally, the adaptive capacity scores for the water asset types are conservative. PUD has operational plans for individual assets, which may address flooding, power outages, and other hazards and events. The protection already conferred by these plans is not captured in the adaptive capacity scores, as the scores are based on limitations and opportunities at the asset type scale rather than for individual assets.

The critical asset types with highest overall vulnerability are wastewater pump stations, which were found to be exposed to all climate change hazards except wildfire, with high potential vulnerability to coastal erosion and precipitation. Heat and wildfire are the most prevalent hazards for this sector, as they impact nearly all water asset types included in this assessment.

Table 25. Vulnerability of Critical Water Asset Types to Climate Change Hazards[28]

	SLR	Storm Surge with SLR	Coastal Erosion	Precipitation	Heat	Wildfire
Dams	N/A	N/A	N/A	High	Low	Medium
Water Pipes	Medium	Medium	High	Medium	N/A	N/A
Wastewater Pipes	Medium	Medium	High	Medium	N/A	N/A
Water Pump Stations	N/A	N/A	N/A	Medium	Medium	High
Wastewater Pump Stations	Low	Medium	High	High	Low	N/A
Distribution Reservoirs	N/A	N/A	N/A	N/A	Medium	Medium
Water Treatment Plants	N/A	N/A	N/A	N/A	Low	Medium
Wastewater Treatment Plants	Low	Low	N/A	N/A	Medium	Medium

Water Asset Consequences

Water assets include those that capture, store, treat, and distribute water supplies and wastewater in the City. In many cases, failure could result in flooding, which could have a variety of damaging consequences. In addition, impacts to the water supply infrastructure could have negative consequences for human health, social equity, and the environment. Impacts that result in flooding could result in impacts to the transportation system such as delays or rerouting. If wastewater systems are impacted, sewage contamination and a loss of the critical service of wastewater removal and treatment could follow, however these are considered to be rare events; the City has many contingencies plans in place to prevent this occurrence.

Illustrative examples of the consequences of water system damage, disruption, and failure are presented in Table 26. This table is provided purely to illustrate potential impacts; it is not meant to imply that these impacts will definitively occur, nor is this list fully comprehensive of all potential consequences to all asset types.

[28] The vulnerability scores were calculated using a combination of spatial asset data provided by the City of San Diego or SanGIS, the best available spatial projections and localized modeling for the chosen climate hazard scenarios, and an assumption of asset type-level (general) of sensitivity and adaptive capacity based on literature reviews and high-level department consultations. The scores reported here do not reflect the vulnerability of specific, individual assets, but rather an assumption of asset type vulnerability. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 26. Illustrative Consequences of Critical Water Asset Damage, Disruption, or Failure

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
Dams	City Services Human Health Natural Resources and Environment Historical, Tribal Cultural, and Archaeological Resources	It is important to note that dams are closely managed in such a way to prevent overtopping or failure and to meet all requirements set forth by the California Division of Safety of Dams. Weather forecasting and water-level management in compliance with these requirements enables safe operation of dams during periods of high precipitation. If it were to happen, dam failure could result in flooding and damages to structures or the environment, depending on the depth and velocity of water. The potential consequences include loss of life and injury, damage to structures and infrastructure, loss of services, and road closures (CVCOG, 2018; NSW Dams Safety Committee, 2011; FEMA, 2012). The risk will depend on volume of water retained at the time of failure, occupancy in the surrounding area and warning time. Given sufficient time to evacuate downstream, loss of life could be minimized but there could be disruptions to daily life from flooding. The Morena Dam has been evaluated and found eligible for historical designation. Additionally, other dams that are not currently designated may be eligible for designation pending evaluation. Damage to these structures could impact their ability to convey historical and cultural information and value (City of San Diego Historic Preservation Planning, 2020).
Pipes and Pump Stations (water and wastewater)	City Services Human Health	Consequences of failure would vary depending on the pipeline and location of failure. While one small pipe or pump may have minimal consequences for the system overall, a large pipe or pump or critical part of the system could have significant negative impacts across the system. Damage to pipes and pumps could result in property damages, loss of production, environmental damages, or human health consequences. For example, leakages due to pipe failure in the wastewater system could release hazardous materials into the environment. Leakages due to pipe failure in the water system could also result in localized flooding, erosion and loss of water service.
Distribution Reservoir	City Services Human Health	If distribution reservoirs are compromised, it could affect potable water service for customers in San Diego.
Water Treatment Plants	City Services Human Health	Water treatment plants play a key role in supplying water to the City. If these facilities were to be compromised by climate-related hazards, it could temporarily limit water supplies in the City.
Wastewater Treatment	City Services	Damage or failure of wastewater treatment plants could have a range of impacts, due primarily to water contamination. In addition, there could be a risk of waterborne illness. In the event of a sewer spill, the

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
Plants	Human Health Natural Resources and Environment	City could be responsible for millions of dollars in fines. However, these are considered to be rare occurrences; the City has many contingencies plans in place to prevent this occurrence. Water quality impacts due to pollution could have ripple effects on habitat or species in the affected area if water is released back into the environment or flooding of wastewater spills into the surrounding environment.

Water Asset Vulnerability to Coastal Hazards

Coastal hazards include sea level rise, storm surge, and erosion. Daily flooding was used to estimate exposure to chronic inundation and represents the extent of flooding that would occur at high tide on average each day under each sea level rise scenario. Storm surge (100-year storm) flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm under each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

The City found that water pipes, wastewater pipes, and wastewater pump stations show low to medium vulnerability to coastal flooding and high vulnerability to coastal erosion. Flooding would not have a severe impact on underground pipes or pump stations, but erosion could compromise the functionality of the system. All erosion scenarios assume 2.0 meters of sea level rise (which is the upper range for 2100).

The results of the vulnerability assessment of critical water asset types to coastal hazards are shown in Table 27, Table 28, and Table 29. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to coastal hazards. Table 30 provides the rationale for the sensitivity and adaptive capacity scores.

Table 27. Vulnerability of Water Critical Asset Types to Sea Level Rise

SLR	Dams	Water Pipes	Waste-water Pipes	Water Pump Stations	Waste-water Pump Stations	Distribution Reservoirs	Water Treat-ment Plants	Waste-water Treat-ment Plants
Exposure	Not ex-posed	High	High	Not exposed	Low	Not exposed	Not Exposed	Low
Sensitivity	N/A	Low	Medium	N/A	Low	N/A	N/A	Medium
Adaptive Capacity	N/A	High	High	N/A	High	N/A	N/A	Medium
Vulnerability	N/A	Medium	Medium	N/A	Low	N/A	N/A	Low

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 28. Vulnerability of Water Critical Asset Types to Storm Surge with Sea Level Rise (One Hundred-Year storm)

Storm Surge with SLR	Dams	Water Pipes	Waste-water Pipes	Water Pump Stations	Waste-water Pump Stations	Distribu-tion Reservoirs	Water Treat-ment Plants	Waste-water Treat-ment Plants
Exposure	Not ex-posed	High	High	Not exposed	High	Not exposed	Not exposed	Low
Sensitivity	N/A	Low	Medium	N/A	Low	N/A	N/A	Low
Adaptive Capacity	N/A	High	High	N/A	High	N/A	N/A	High
Vulnerability	N/A	Medium	Medium	N/A	Medium	N/A	N/A	Low

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 29. Vulnerability of Water Critical Asset Types to Coastal Erosion at Medium-High Risk Aversion Scenario of 2m of Sea Level Rise

Coastal Erosion	Dams	Water Pipes	Waste-water Pipes	Water Pump Stations	Waste-water Pump Stations	Distribu-tion Reservoirs	Water Treatment Plants	Waste-water Treatment Plants
Exposure	Not exposed	High	High	Not exposed	High	Not exposed	Not exposed	Not exposed
Sensitivity	N/A	High	High	N/A	High	N/A	N/A	N/A
Adaptive Capacity	N/A	Low	Low	N/A	Low	N/A	N/A	N/A
Vulnerability	N/A	High	High	N/A	High	N/A	N/A	N/A

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Water Asset Exposure to Coastal Hazards

Of all water asset types, wastewater pump stations face the highest relative exposure to sea level rise: seven out of the eight primary wastewater pump stations face exposure to sea level rise starting at 1.0 m of sea level rise (2100 timeframe). Water pipes and wastewater pipes face

Sea Level Rise Projections for San Diego

2030: 0.25 m

2050: 0.5 to 0.75 m

2100: 1.0 to 2.0 m

less exposure: less than five percent of both pipe types are projected to be exposed to sea level rise by 2100 (Figure 17).

Water and wastewater pipes and wastewater pump stations also face flooding from storm surge with sea level rise (100-year flood) (Figure 18). In this case, half of wastewater pump stations may be exposed starting at 0.25 meters of sea level rise (2030), with sixty-three percent of wastewater pump stations potentially exposed to flooding from storm surge with sea level rise by 2100 (2.0 m sea level rise, which is the upper range for 2100). Less than five percent of water and wastewater pipes may be exposed to storm surge with sea level rise.

Water pipes, wastewater pipes, and wastewater pump stations face limited exposure to cliff erosion (Figure 19). Cliff erosion poses the greatest risk for wastewater pump stations: one location, or thirteen percent of total wastewater pump stations, may be exposed to cliff erosion.

A small portion of water pipes, wastewater pipes, and wastewater pump stations may be exposed to beach erosion (Figure 20). As with cliff erosion, wastewater pump stations face the greatest relative exposure to beach erosion, with twenty-five percent of these assets facing exposure. The figures below show water asset exposure to sea level rise, sea level rise plus storm surge, and erosion, respectively. The value after each asset name indicates the total number of assets in that asset type. The colored bars for each increment show how many additional assets become exposed under that sea level rise or erosion scenario.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the coastal hazard scenarios.

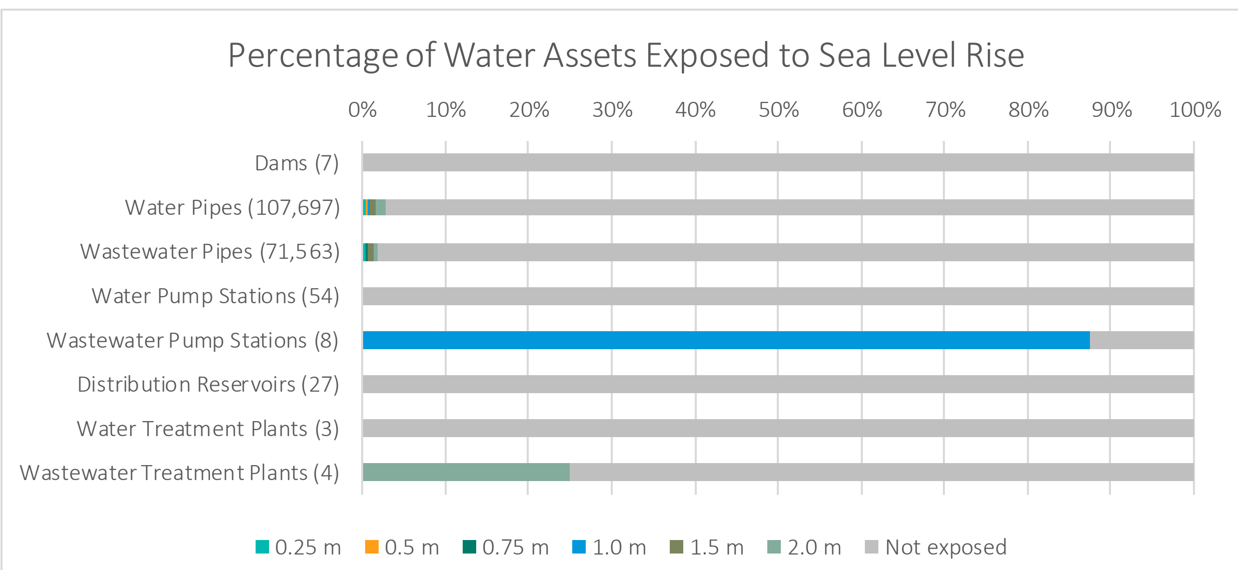

Figure 17. Water critical assets exposed to sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario.

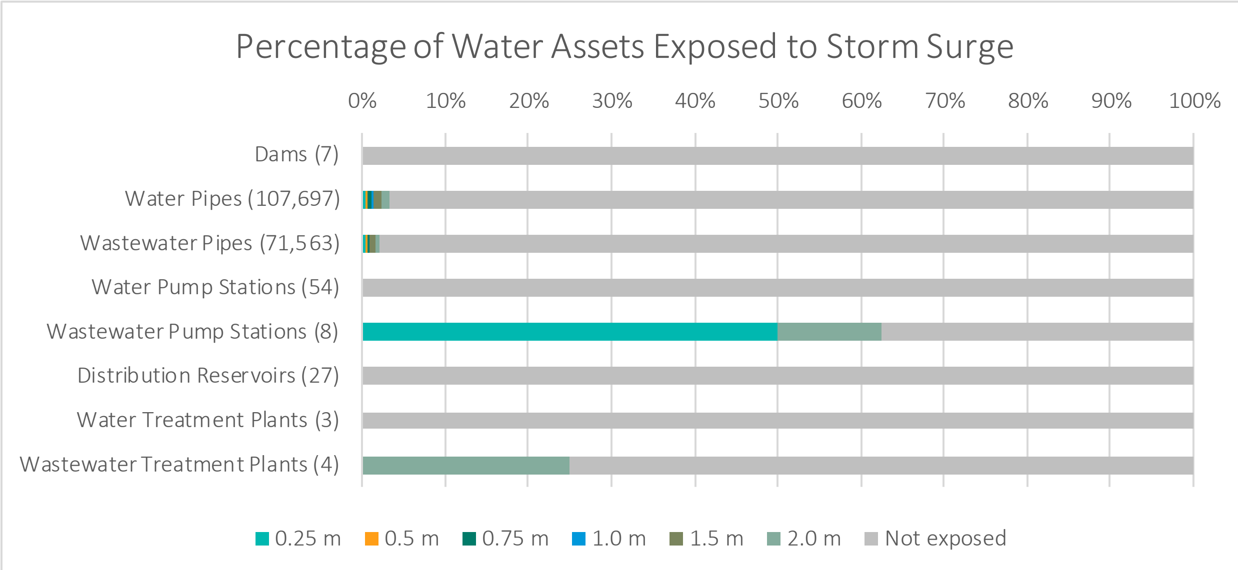

Figure 18. Water critical assets exposed to storm surge with sea level rise; this includes the 100-year storm on top of sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario. Assets would be exposed to storm surge prior to being exposed to average daily flooding, so more assets in this graph tend to be exposed under lower sea level rise amounts.

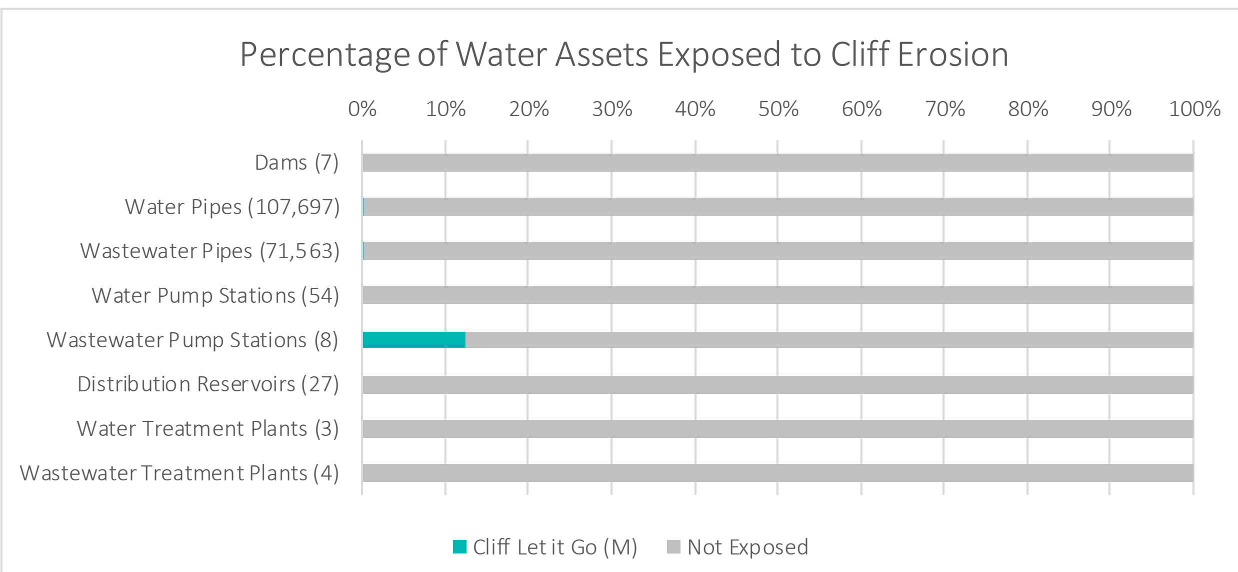

Figure 19. Water critical assets exposed to cliff erosion. The value after each asset name indicates the asset count. "Cliff let it go" represents the number of assets exposed to erosion if the City does not implement coastal armoring and allows cliff retreat and erosion.

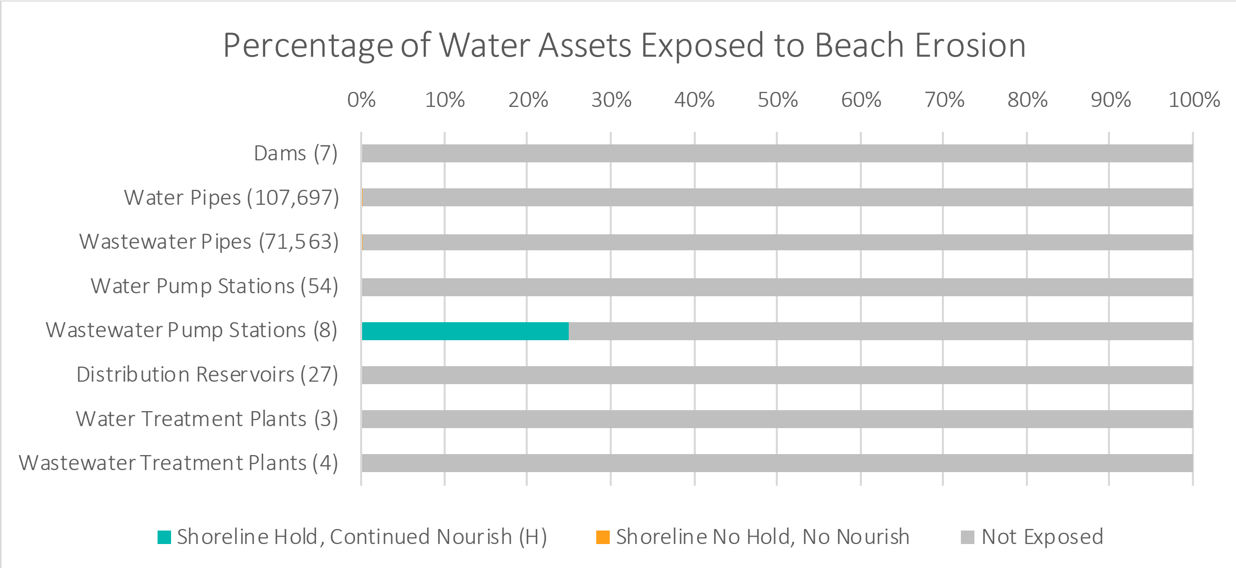

Figure 20. Water critical assets exposed to beach erosion. The value after each asset name indicates the asset count. "Shoreline Hold, Continued Nourish" represents the number of assets exposed to flooding if the City continues beach nourishment and sea wall repair, while "Shoreline No Hold, No Nourish" represents the number of assets exposed if the City were to stop beach nourishment and seawall repair.

Water Asset Sensitivity and Adaptive Capacity to Coastal Hazards

Based on the exposure assessment, the City reviewed the sensitivity and adaptive capacity of water pipes, wastewater pipes, wastewater pump stations, and wastewater treatment plants to coastal flooding and erosion. The results of this analysis are shown in Table 30.

Table 30. Sensitivity and Adaptive Capacity of Water Critical Asset Types to Coastal Hazards

Water Pipes	
SLR Sensitivity: Low Since pipes are buried underground, they will likely suffer little damage from flooding (ICLEI, 2017). However, chronic inundation could decrease accessibility of the pipes, and sitting in corrosive saltwater for extended periods of time could shorten pipes' useful life (Consultation with City of San Diego PUD, 2020).	*SLR Adaptive Capacity: High* Water pipes are a networked system, so redundancy overall is quite high (Consultation with City of San Diego PUD, 2019). A majority of the City's water pipes are still within their useful life, though they might require routine rehabilitation and replacement within this study's timeframe (to 2100). The cost to replace pipes could be expensive; however PUD has planned within the department's Capital Improvements Program to rehabilitate and replace pipes as necessary (City of San Diego, 2019).
Storm Surge with SLR Sensitivity: Low Since pipes are buried underground, they will likely suffer minimal damage from flooding (ICLEI,	*Storm Surge with SLR Adaptive Capacity: High* Water pipes are a networked system, so redundancy overall is quite high (Consultation

2017).	with City of San Diego PUD, 2019). A majority of the City's water pipes are still within their useful life, though they might require routine rehabilitation and replacement within this study's timeframe (to 2100). The cost to replace pipes could be expensive; however PUD has planned within the department's Capital Improvements Program to rehabilitate and replace pipes as necessary (City of San Diego, 2019).
Coastal Erosion Sensitivity: High Pipes are sensitive to erosion, as this hazard could compromise the functionality of the system (ICLEI, 2017).	*Coastal Erosion Adaptive Capacity: Low* Pipes have low adaptive capacity, as coastal erosion that impacts one location could have implications for the system overall (ICLEI, 2017). PUD is currently engaging in a study on coastal erosion at certain locations to further investigate the issue.
Wastewater Pipes	
SLR Sensitivity: Medium Since pipes are buried underground, they will likely suffer little damage from flooding (ICLEI, 2017). However, chronic inundation could decrease accessibility of the pipes, and sitting in corrosive saltwater for extended periods of time could shorten pipes' useful life. Additionally, the potential for seawater to inflow and infiltrate into wastewater pipes may increase flows to the wastewater treatment system (Consultation with City of San Diego PUD, 2020).	*SLR Adaptive Capacity: High* Wastewater pipes are not a networked system, so this system has less overall redundancy (Consultation with City of San Diego PUD, 2019). A majority of the City's wastewater pipes are still within their useful life, though they might require routine rehabilitation and replacement within this study's timeframe (to 2100). The cost to replace pipes could be expensive; however PUD has planned within the department's Capital Improvements Program to rehabilitate and replace pipes as necessary (City of San Diego, 2019).
Storm Surge with SLR Sensitivity: Medium Since pipes are buried underground, they will likely suffer minimal damage from flooding (ICLEI, 2017). However, the potential for seawater to inflow and infiltrate into wastewater may increase flows to the wastewater treatment system (Consultation with City of San Diego PUD, 2020).	*Storm Surge with SLR Adaptive Capacity: High* Wastewater pipes are not a networked system, so this system has less overall redundancy (Consultation with City of San Diego PUD, 2019). A majority of the City's wastewater pipes are still within their useful life, though they might require routine rehabilitation and replacement within this study's timeframe (to 2100). The cost to replace pipes could be expensive; however PUD has planned within the department's Capital Improvements Program to rehabilitate and

	replace pipes as necessary (City of San Diego, 2019).
Coastal Erosion Sensitivity: High Pipes are sensitive to erosion, as this hazard could compromise the functionality of the system (ICLEI, 2017).	*Coastal Erosion Adaptive Capacity: Low* Pipes have low adaptive capacity, as coastal erosion that impacts one location could have implications for the system overall (ICLEI, 2017). PUD is currently engaging in a study on coastal erosion at certain locations to further investigate the issue.
Wastewater Pump Stations	
SLR Sensitivity: Low Exposure to flooding would have little impact on pump stations (ICLEI, 2017).	*SLR Adaptive Capacity: High* Impaired components may be isolated for repair, if necessary, without significant disruption to the system (ICLEI, 2017). However, if an entire pump station were to be shut down, the risk for spills and damage to the environment would increase (Consultation with City of San Diego PUD, 2020). Each pump station has an operations plan and emergency plan in place (Consultation with City of San Diego PUD, 2019). All major pump stations have onsite backup power generation to maintain functionality in the event of an outage (Consultation with City of San Diego PUD, 2020).
Storm Surge with SLR Sensitivity: Low Exposure to flooding would have little impact on pump stations (ICLEI, 2017).	*Storm Surge with SLR Adaptive Capacity: High* Impaired components within a station may be isolated for repair, if necessary, without significant disruption to the system (ICLEI, 2017). However, if an entire pump station were to be shut down, the risk for spills and damage to the environment would increase (Consultation with City of San Diego PUD, 2020). Each pump station has an operations plan and emergency plan in place (Consultation with City of San Diego PUD, 2019). All major pump stations have onsite backup power generation to maintain functionality in the event of an outage (Consultation with City of San Diego PUD, 2020).
Coastal Erosion Sensitivity: High Erosion could severely impact the system and compromise its functionality (ICLEI, 2017).	*Coastal Erosion Adaptive Capacity: Low* While not currently in place, there are measures available that could protect pump stations from coastal erosion. These include natural structures that minimize wave energy and erosion (e.g.,

	living shorelines) as well as traditional engineered structures (e.g., rip rap, sea walls) (Consultation with City of San Diego PUD, 2020).
Wastewater Treatment Plants	
SLR Sensitivity: Medium Wastewater treatment plants are designed for contingencies such that the plant could stay functional even if some parts fail. Backup generators are always available in the event of an outage. Coastal plants (such as Point Loma) are designed for some coastal impacts, meaning that some equipment is marine rated (e.g., units are housed or coated to prevent corrosion), but coatings break down over time. Chronic inundation could pose a threat to access and plant longevity (Consultation with City of San Diego PUD, 2019).	*SLR Adaptive Capacity: Medium* The current design of the wastewater treatment plants and requirement of on-site backup generators means that these facilities are well-prepared for coastal impacts. However, if inundation becomes chronic, additional engineering solutions and site improvements will be evaluated. PUD is currently maximizing water reuse, which will reduce the volume of wastewater being treated at these plants into the future (Hummel, 2018).
Storm Surge with SLR Sensitivity: Low Wastewater treatment plants are designed for contingencies such that the plant could stay functional even if some parts fail. Backup generators are always available in the event of an outage. Coastal plants (such as Point Loma) are designed for some coastal impacts, meaning that some equipment is marine rated (e.g., units are housed or coated to prevent corrosion), but coatings break down over time (Consultation with City of San Diego PUD, 2019).	*Storm Surge with SLR Adaptive Capacity: High* The current design of wastewater treatment plants and requirement of on-site backup generators means that these facilities are well prepared for coastal storms (Consultation with City of San Diego PUD, 2019).
Coastal Erosion Sensitivity: Not exposed	*Coastal Erosion Adaptive Capacity: Not exposed*

Water Asset Vulnerability to Precipitation-driven Flooding

The City found that all water critical asset types, except distribution reservoirs, wastewater treatment plants, and water treatment plants are vulnerable to precipitation-driven flooding. Distribution reservoirs and wastewater and water treatment plants are located outside of both the FEMA 100-year and 500-year floodplains, and therefore not considered vulnerable.

The results of the vulnerability assessment of water critical asset types to precipitation-driven flooding are shown in Table 31. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to precipitation-driven flooding. Table 32 provides the rationale for the sensitivity and adaptive capacity scores.

This assessment focused on precipitation-driven flooding, using the FEMA 100- and 500-year floodplains to estimate exposure. However, increases in the frequency and intensity of drought conditions is also anticipated. Drought is a region-wide issue that could affect both the locally collected water supply and imported water supply. Scientists in California are actively studying drought as a climate change related hazard (Pierce, 2018; California Energy Commission, 2020), and San Diego is pursuing projects such as the Pure Water Program, which contributes to a more resilient water supply. The Public Utilities Department also considered climate change in the development of its most recent long-term water sourcing plan (Consultation with City of San Diego PUD, 2020).

Table 31. Vulnerability of Water Critical Asset Types to Precipitation-driven Flooding

	Dams	Water Pipes	Waste-water Pipes	Water Pump Stations	Waste-water Pump Stations	Distribution Reservoirs	Water Treatment Plants	Waste-water Treat-ment Plants
Exposure	High	High	High	Medium	High	Not exposed	Not exposed	Not exposed
Sensitivity	High	Low	Low	Medium	High	N/A	N/A	N/A
Adaptive Capacity	High	High	High	Medium	Medium	N/A	N/A	N/A
Vulnerability	High	Medium	Medium	Medium	High	N/A	N/A	N/A

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Water Asset Exposure to Precipitation-driven Flooding

Of the water critical asset types, dams, water and wastewater pipes, and water and wastewater pump stations face exposure to precipitation-driven flooding, as shown in Figure 21.

Dams are the asset type facing highest proportional exposure, as twenty-nine percent of dams face exposure to the 100-year precipitation-driven flooding event. Twenty-five percent of wastewater pump stations fall within the 100-year floodplain. Two percent of water pump stations are exposed to precipitation; all of these are in the 500-year floodplain. Roughly five percent of water pipes and wastewater pipes lie in a floodplain.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to precipitation-driven flooding.

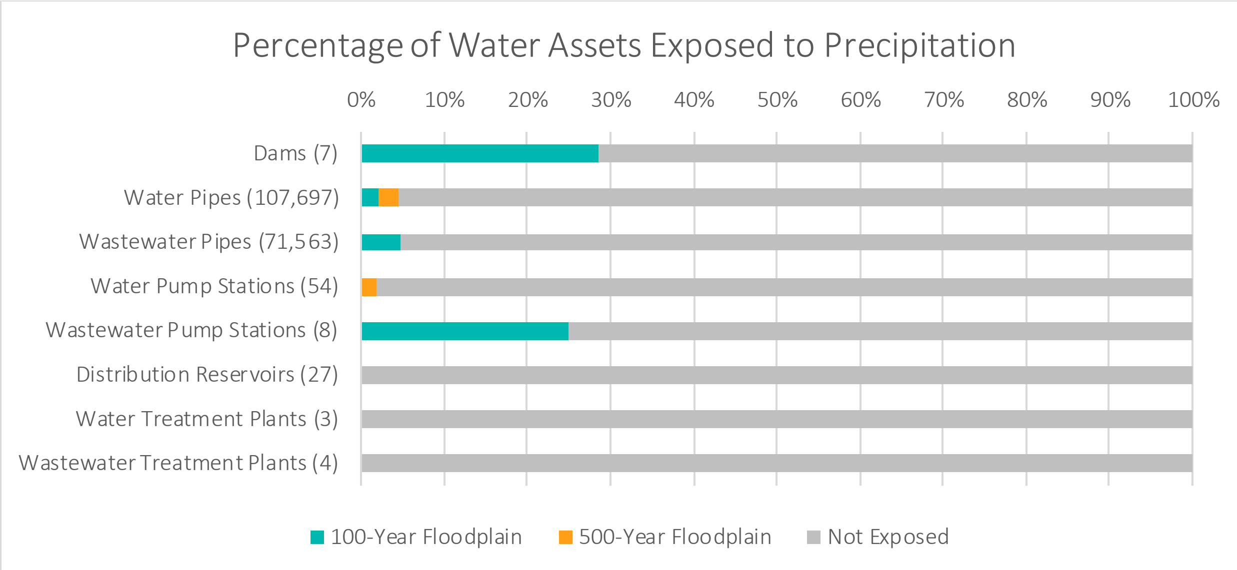

Figure 21. Water critical assets exposed to precipitation. The value after each asset name indicates the asset count. All assets in the 100-year floodplain also lie in the 500-year floodplain; the orange-colored bar for the 500-year floodplain shows assets that are outside the 100-year floodplain but experience flooding under more extreme precipitation events.

Water Asset Sensitivity and Adaptive Capacity to Precipitation-driven Flooding

Based on the findings of the exposure assessment, the City included dams, both types of pipes and pump stations, and wastewater treatment plants in the sensitivity and adaptive capacity analysis. The results of this analysis are shown in Table 32.

Table 32. Sensitivity and Adaptive Capacity of Water Critical Asset Types to Precipitation-driven Flooding

Dams	
Precipitation Sensitivity Rating: High Extreme precipitation is often the cause for dam overtopping and/or failure across the United States (Association of State Dam Safety Officials, 2019; Smith & Schwartz, 2019). Higher precipitation may increase sediment load in water held by dams, which may benefit from dredging to restore reservoir capacity and function (Consultation with City of San Diego Parks and Recreation Department, 2019). However, many dams nationwide are also functional reservoirs, so they are sited in areas planned and expected to experience high precipitation (e.g., floodplains) in order to mitigate floods and capture water for treatment and use. As a result, dams are generally well-managed for high precipitation events.	*Precipitation Adaptive Capacity Rating: High* The City actively manages the raw water reservoir levels by keeping the water levels low throughout the rainy season, which reduces the risk for dam overtopping or failure (Consultation with City of San Diego PUD, 2019).

Water and Wastewater Pipes	
Precipitation Sensitivity Rating: Low Since pipes are buried underground, they will likely suffer little damage from being located within the floodplains (ICLEI, 2017). However, there is the potential for exposure when precipitation leads to washouts.	*Precipitation Adaptive Capacity Rating: High* Water pipes are a networked system, so redundancy overall is quite high. However, this is not the case for the wastewater system; this system has less overall redundancy (Consultation with City of San Diego PUD, 2019). A majority of the City's water and wastewater pipes are still within their useful life, though they might require routine rehabilitation and replacement within this study's timeframe (to 2100). The cost to replace pipes could be expensive, but PUD has planned within the department's Capital Improvements Program to rehabilitate and replace pipes as necessary (City of San Diego, 2019).
Water Pump Stations	
Precipitation Sensitivity Rating: Medium Underground facilities can be susceptible to flooding. If storms result in power outages, any pump stations without emergency backup generators may be temporarily non-functional (USAID, 2014).	*Precipitation Adaptive Capacity Rating: Medium* Portable pumps could be moved to affected facilities if access roads are not also flooded (Consultation with City of San Diego PUD, 2019). Above grade pump stations can be protected against flooding through design/location of the pump station and/or through protection measures such as sandbags and sump pumps.
Wastewater Pump Stations	
Precipitation Sensitivity Rating: High Precipitation-based flooding is the main climate hazard of concern for wastewater pump stations. Heavy rainfall could lead to failure of pump stations or generator failure (Consultation with City of San Diego PUD, 2019).	*Precipitation Adaptive Capacity Rating: Medium* Portable pumps could be moved to affected facilities if access roads are not also flooded and thus preventing access. Pure Water can reduce the volume of wastewater being handled at some pump stations and at the WWTP. All major wastewater pump stations have back-up power options such as natural gas engines or additional generators to prevent interruptions during a power outage.

Water Asset Vulnerability to Heat

The City found that all water critical asset types are exposed to heat except water and wastewater pipes. Dams, wastewater pump stations, water treatment plants and wastewater treatment plants showed medium to low exposure, with assets sitting in UHI zones scoring up to eighty. Water pump stations and distribution reservoirs showed high exposure, with one asset in each asset type sitting in an 80-100 UHI zone. As water and wastewater pipes are underground, and ground temperature does not strongly correlate to ambient air temperature, these two asset types are considered not exposed, and therefore not vulnerable, to heat for this analysis.

The results of the vulnerability assessment of water critical asset types to heat are shown in Table 33. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to heat. Table 34 provides the rationale for the sensitivity and adaptive capacity scores.

Table 33. Vulnerability of Water Critical Asset Types to Heat

	Dams	Water Pipes	Waste-water Pipes	Water Pump Stations	Waste-water Pump Stations	Distribution Reservoirs	Water Treatment Plants	Wastewater Treatment Plants
Exposure	Medium	Not exposed	Not exposed	High	Low	High	Medium	Medium
Sensitivity	Low	N/A	N/A	Low	Low	Low	Low	Medium
Adaptive Capacity	High	N/A	N/A	High	High	High	High	Medium
Vulnerability	Low	N/A	N/A	Medium	Low	Medium	Low	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10.

Water Asset Exposure to Extreme Heat

The heat island scenarios are represented as zones with scores of 0 to 100+, with higher scores denoting hotter areas (CalEPA, 2019).[29] A score of zero indicates that there is no difference in temperature

In San Diego, coastal areas are relatively cooler than inland areas due to the moderating impacts of the ocean and offshore winds. This coastal effect dominates the urban heat island effect in the City.

[29] The urban heat island index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period. To estimate the total number of degrees Fahrenheit per day, divide the Index by 24 hours and multiply by 1.8 degrees. Higher scores denote hotter areas.

over time between an urban Census tract and nearby upwind rural reference points. A score of 100 indicates that there is a difference of 7.5 degrees Fahrenheit (approx. 4.2 degrees Celsius) between these tracts over 24 hours.

Dams, water pump stations, distribution reservoirs, water treatment plants, and wastewater treatment plants have all their assets facing some level of heat exposure (Figure 22). Only thirteen percent of wastewater pump stations face some level of exposure to heat. As water and wastewater pipes are underground, and ground temperature does not strongly correlate to ambient air temperature, these two asset types are considered not exposed to heat.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the heat levels.

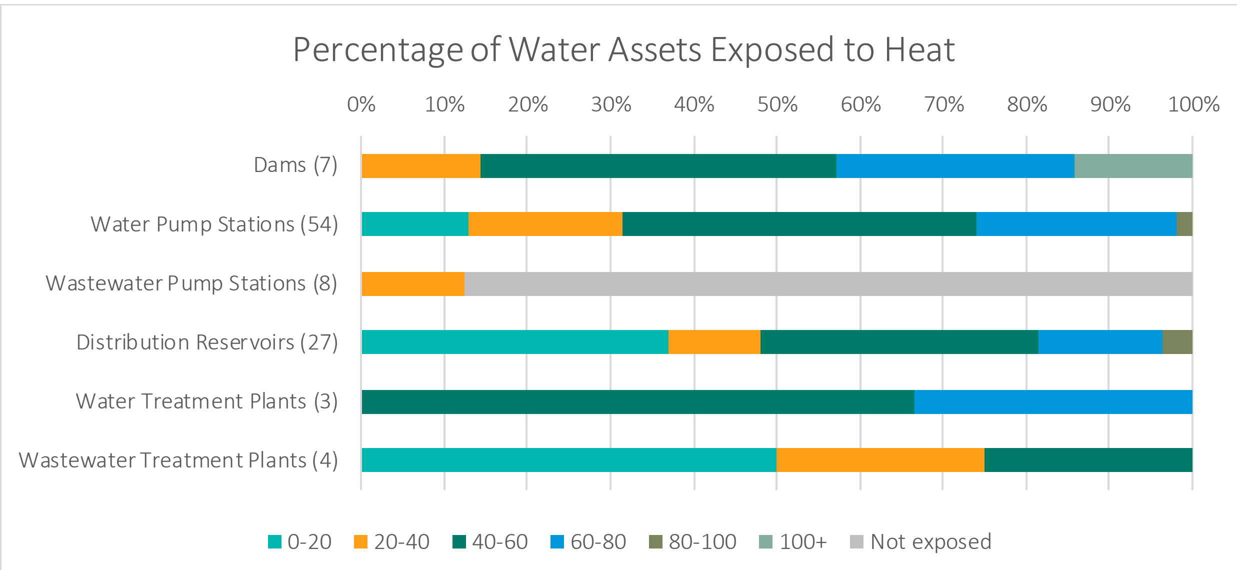

Figure 22. Water critical assets exposed to extreme heat. The value after each asset name indicates the asset count. The colored bars represent exposure to different ranges in the UHI index, with higher UHI values denoting hotter areas and therefore increased exposure to heat.

Water Asset Sensitivity and Adaptive Capacity to Heat

Based on the exposure analysis, the City considered the sensitivity and adaptive capacity of all water critical asset types except water and wastewater pipes to heat. The results of this analysis are presented in Table 34 below.

Table 34. Sensitivity and Adaptive Capacity of Water Critical Asset Types to Heat

Dams	
Heat Sensitivity Rating: Low Higher heat may increase water loss due to increases in evaporation rates.	*Heat Adaptive Capacity Rating:* High Adaptation to heat is likely not necessary for dams.
Water and Wastewater Pump Stations	
Heat Sensitivity Rating: Low Higher heat may stress electrical equipment. In	*Heat Adaptive Capacity Rating:* High Portable pumps, backup pumps, and emergency

the event of blackouts or brownouts, water service may be interrupted, and water treatment may be disrupted (U.S. General Services Administration, 2015). However, pump stations that are underground are less sensitive to changes in ambient air temperature.	generators can be employed in the event of a power outage (Consultation with City of San Diego PUD, 2019). All major pump stations have onsite backup power generation to maintain functionality in the event of an outage (Consultation with City of San Diego PUD, 2020).
Distribution Reservoirs	
Heat Sensitivity Rating: Low San Diego's distribution reservoirs are covered, so the water contained within these resources would likely not evaporate. Additionally, reservoirs are designed with expandable joints and flexible coatings to prevent leakage or structural damage caused by temperature change (Consultation with City of San Diego PUD, 2019).	*Heat Adaptive Capacity Rating: High* Adaptation to heat is likely not necessary for distribution reservoirs outside of the existing operational strategies currently used, particularly those aimed at maintaining water quality, as heat degrades disinfectants. To address this, tanks are operated with daily volume turnover and provided with inlet/outlet systems designed to create internal tank mixing. Reservoir temperatures and disinfectant residuals are continuously monitored at potable reservoirs and action levels are in place to identify and resolve water quality problems (Consultation with City of San Diego PUD, 2020).
Water Treatment Plants	
Heat Sensitivity Rating: Low The U.S. Environmental Protection Agency (EPA) requirement to have backup generators at all treatment facilities reduces these facilities' sensitivity to blackouts and brownouts during extreme heat events (Consultation with City of San Diego PUD, 2019).	*Heat Adaptive Capacity Rating: High* All water treatment plants have emergency backup power or dual power sources in the event of an outage. In addition, the City has a contingency plan in place: if one plant is down, the City could switch to one of the other two water treatment facilities. As needed, the City could also purchase water from the County Water Authority (Consultation with City of San Diego PUD, 2019).
Wastewater Treatment Plants	
Heat Sensitivity Rating: Medium Increases in heat could damage equipment and wastewater treatment plants in several ways. Higher temperatures increase production of hydrogen sulfide, which corrodes infrastructure and equipment (ICLEI, 2012). Higher heat may stress and degrade electrical equipment. In addition, higher heat may lead to	*Heat Adaptive Capacity Rating: Medium* All wastewater treatment plants have emergency backup power or dual power sources in the event of an outage. Wastewater treatment plants include robust ventilation and cooling systems as part of their design. However, ambient design temperatures were put in place decades ago and may now be

lower water flows due to evaporation and drought, which could decrease treatment efficiency (USAID, 2014).	outdated. While the City plans on using projected temperatures to design treatment facilities moving forward, older facilities may have less ability to adapt to heat (Consultation with City of San Diego PUD, 2019).

Water Asset Vulnerability to Wildfires

The City found that all water critical asset types except water pipes, wastewater pipes, and wastewater pump stations face exposure to wildfire. In particular, water pump stations show high vulnerability: high exposure and high sensitivity are enough to rate them as highly vulnerable, despite medium adaptive capacity. While water pipes and wastewater pipes cross through areas within the different fire hazard zones, these asset types are underground and therefore were assumed to not be at risk of exposure to wildfire (and therefore not vulnerable for the sake of this analysis).

The results of the vulnerability assessment of water critical asset types to wildfire are shown in Table 35. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to wildfire. Table 36 provides the rationale for the sensitivity and adaptive capacity scores.

Table 35. Vulnerability of Water Critical Asset Types to Wildfire

	Dams	Water Pipes	Waste-water Pipes	Water Pump Stations	Waste-water Pump Stations	Distribu-tion Reservoirs	Water Treatment Plants	Waste-water Treatment Plants
Exposure	High	Not exposed	Not exposed	High	Not exposed	High	Low	Medium
Sensitivity	Low	N/A	N/A	High	N/A	Low	High	High
Adaptive Capacity	High	N/A	N/A	Medium	N/A	High	High	Medium
Vulnerability	Medium	**N/A**	**N/A**	High	**N/A**	Medium	Medium	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Water Asset Exposure to Wildfire

All water critical asset types except water pipes, wastewater pipes, and wastewater pump stations may be exposed to wildfire (Figure 23). Water and wastewater pipes are underground and therefore were assumed to not be at risk of exposure to wildfire. All four wastewater treatment plants face exposure, with three facing medium exposure and one facing low exposure. There is one dam, thirty-two water pump stations, and fifteen distribution reservoirs facing high exposure to wildfire.

Wildfire Hazard Zones for San Diego

High: Native vegetation and 100-foot setback zones

Medium: 300-foot setback zone

Low: Fire hazard zone outside native vegetation zone and setbacks

See <u>Appendix C: Exposure Data</u> for more detailed information on the number of assets exposed to each of the fire hazard zones.

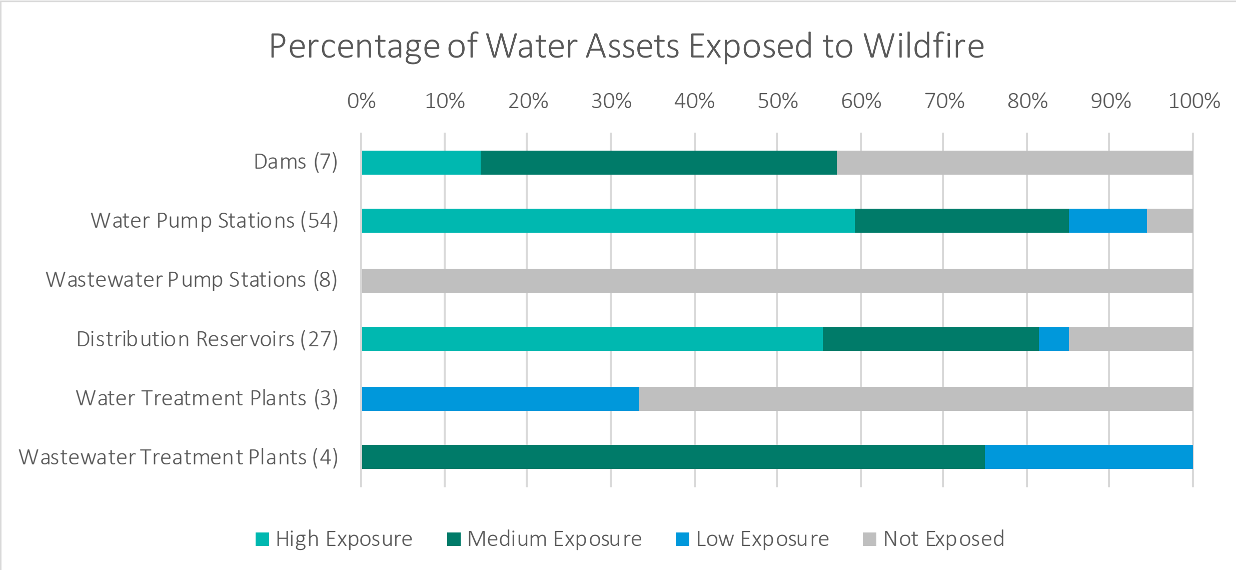

Figure 23. Water critical assets exposed to wildfire. The value after each asset name indicates the asset count.

Water Asset Sensitivity and Adaptive Capacity to Wildfire

Based on the exposure analysis, the City assessed the sensitivity and adaptive capacity of all critical water asset types except water pipes, wastewater pipes, and wastewater pump stations to wildfire. The results of this analysis are shown in Table 36.

Table 36. Sensitivity and Adaptive Capacity of Water Critical Asset Types to Wildfire

Dams	
Wildfire Sensitivity Rating: Low Because dams are always made of concrete or earth (materials that are not sensitive to fire), dams will not fail due to wildfire (Consultation with City of San Diego PUD, 2019).	*Wildfire Adaptive Capacity Rating: High* In general, there is defensible space around dams; City staff regularly clean the landscape (Consultation with City of San Diego PUD, 2019).
Water Pump Stations	
Wildfire Sensitivity Rating: High Most pump stations are above ground (Consultation with City of San Diego PUD, 2019), which renders them more susceptible to wildfire damage.	*Wildfire Adaptive Capacity Rating: Medium* Backup generators are available to keep pump stations running, assuming wildfire does not prevent access (City of San Diego, 2007). However, replacement costs of pump stations could be relatively high (e.g., Pump Station 81 required $245,705 in debris removal and repair after the October 2007 wildfires) (City of San Diego, 2007).
Distribution Reservoirs	

Wildfire Sensitivity Rating: Low Wildfires increase water demand, which could put pressure on the water supply.	*Wildfire Adaptive Capacity Rating: High* The potable water system is designed to operate with multiple fail-safes and operational mechanisms to address outages (Consultation with City of San Diego PUD, 2020).
Water Treatment Plants	
Wildfire Sensitivity Rating: High Wildfires could directly burn and damage water treatment plants. This could lead to a plant shutdown.	*Wildfire Adaptive Capacity Rating: High* The areas within the fence line of facilities are landscaped and maintained to comply with the fire code. Treatment plants are also typically within City limits and not in rural areas where there is a lot of vegetation. All water treatment plants have emergency backup power or dual power sources in the event of an outage. Additionally, control rooms and other sensitive areas have sprinklers. In addition, the City has a contingency plan in place: if one plant is down, the City switches to one of the other two treated water facilities. The City could also buy water from the County Water Authority if necessary (Consultation with City of San Diego PUD, 2019).
Wastewater Treatment Plants	
Wildfire Sensitivity Rating: High Wildfires could directly burn and damage wastewater treatment plants. This could lead to untreated wastewater being released, posing environmental and human health hazards. Fires could also cut off access to these plants. The greatest risk posed by fire, however, is the loss of electrical transformers or other electrical equipment at the plant, which are needed whether power is being sourced from a power utility or the plant's emergency generators (Consultation with City of San Diego PUD, 2020).	*Wildfire Adaptive Capacity Rating: Medium* The areas within the fence line of facilities are landscaped and maintained to comply with the fire code. Wastewater treatment plants are also typically within City limits and not in rural areas with plentiful fuel for wildfires. Some wastewater treatment plants are built with fire-retardant walls. If the level of sewage is "high," an alarm is sent to the City and the emergency plan is implemented. The plants also contain fire alarm systems, and some have sprinklers (Consultation with City of San Diego PUD, 2019).

Transportation and Storm Water Vulnerability Findings

Transportation and Storm Water assets include those managed by the City's Transportation and Storm Water department and Real Estate Assets Department.[30] The following asset types are considered critical and were evaluated for vulnerability: City-operated airports, bridges, major arterials, drain pump stations, storm water outfalls, and levees.[31] Not all assets in this list were found to be exposed to climate hazards.

This assessment includes the City-operated airports Brown Field Municipal Airport (KSDM) and Montgomery-Gibbs Executive Airport (KMYF) but does not include San Diego International Airport, which is owned by the San Diego Regional Airport Authority. These City-owned airports include sensitive habitats and open space areas that are considered and discussed under the "Open Space and Environment" section below.

Other Transportation Assets

The City of San Diego also considered the exposure of state (Caltrans) highways and freeways, as they are part of the transportation network in the City but not owned or managed by the City. This information is found in the "Non-City-Owned Resources" section near the end of this report.

The City did not include transit infrastructure in this vulnerability assessment, as SANDAG received a Caltrans grant to evaluate the resilience of the transit system.

Bridges often have mixed ownership between the City and State: there are 126 bridges in the City for which the City is responsible for maintenance of the bridge deck, railing, streetlights, and improvements above the superstructure of the bridge, while Caltrans is responsible for the maintenance of the superstructure and substructure of the bridge. Bridges and major arterials are broken down into roadway segments as defined in the City's asset management system.

The storm water outfalls, drain pump stations and levees are part of a larger storm water conveyance system that includes channels and underground pipes. While a significant portion of this assessment focuses on the aboveground assets, underground storm water infrastructure could be critically impacted by the changes in precipitation patterns and levels (i.e. inches of rainfall per year, plus duration and intensity of rainfall events).

The results of the vulnerability assessment for transportation and storm water asset types are shown in Table 37. "N/A" indicates that the assets were not found to be exposed to the hazard, so sensitivity and adaptive capacity were not assessed, and the asset types were determined to not be vulnerable.

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[30] The Real Estate Assets Department (READ) manages the City-owned airports. All other transportation assets are managed by the Transportation and Storm Water Department (TSWD).
[31] The levees followed a different exposure analysis than the other assets in this vulnerability assessment. More information is provided in the sections below.

The City found that all transportation and storm water critical asset types face exposure to all hazards, except for airports, which only face exposure to heat and wildfire.

Coastal flooding, coastal erosion, and wildfire are priority hazards, as nearly all asset types are highly vulnerable to these hazards. All asset types besides airports show medium to high vulnerability to precipitation, and all asset types besides drain pump stations and levees show medium vulnerability to heat.

Table 37. Vulnerability of Transportation and Storm Water Critical Asset Types to Climate Change Hazards[32]

	Sea Level Rise (SLR)	Storm Surge with SLR	Coastal Erosion	Precipitation	Heat	Wildfire
Airports	N/A	N/A	N/A	**Low**	Medium	**High**
Bridges	**High**	Medium	**High**	Medium	Medium	**High**
Major Arterials	**High**	Medium	Medium	Medium	Medium	**High**
Drain Pump Stations	**High**	**High**	N/A	High	**Low**	**High**
Outfalls	**High**	**High**	**High**	**High**	Medium	Medium
Levees	**Low**	**Low**	N/A	Medium	**Low**	Medium

City-Managed Trees

While not a part of this current vulnerability assessment, the City also considers its urban trees to be critical assets. The City has approximately 200,000 street trees, 600,000 park trees, and an unknown number of trees on other public properties owned and managed by the City. These trees provide many benefits to the City's communities, including but not limited to reduction of storm water runoff, reduction in electricity use during the summer, mitigation against the urban heat island effect, and a reduction in airborne particulates. A recent inventory showed that approximately 70,000 trees stored over 12,800 tons of carbon worth $1.6 million. Under Strategy 5 of the City's CAP, the tree canopy cover is targeted to be increased to 15 percent by 2020 and 35 percent by 2035.

Trees are critical assets to the City's communities and could be affected by sea level rise, drought, heat, and wildfire. Increased sea levels could affect City trees in low coastal areas. This could affect existing trees as well as reduce areas for new trees to grow. Almost all tree species in the City are sensitive to salts (brackish water). Recent droughts have also shown that some trees are highly sensitive to changes in

[32] The vulnerability scores were calculated using a combination of spatial asset data provided by the City of San Diego or SanGIS, the best available spatial projections and localized modeling for the chosen climate hazard scenarios, and an assumption of asset type-level (general) of sensitivity and adaptive capacity based on literature reviews and high-level department consultations. The scores reported here do not reflect the vulnerability of specific, individual assets, but rather an assumption of asset type vulnerability. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

temperature and changes in amounts of precipitation. Several years ago, a large grove of coastal redwoods died in Balboa Park after a long period without water. Changes in climate, in combination with recent droughts, have additionally made trees more susceptible to pests such as the shot hole borer, gold spotted borer and the South American palm weevil. All three pests have affected trees in San Diego, creating deteriorating tree conditions that increase risk to people and property.

Sudden impacts from precipitation events, drought, pests, or wildfire could greatly affect a large number of trees in a given area, creating a significant risk to public safety that often needs immediate action to address. The costs to remove and replace trees could be significant. A future, tree-specific, vulnerability assessment would provide more detailed analysis of the specific climate change driven impacts to trees.

Transportation and Storm Water Consequences

Transportation Consequences

Transportation systems are vital for economic vitality and societal functioning of San Diego. Disruptions could delay or inhibit the movement of goods and people, including delays for emergency vehicles and disruptions to daily life. The extent of damage would depend on the location and traffic load of the asset. The consequences would also depend on the level of redundancy within the system that allows travel to continue despite damage to one part of the system.

Illustrative examples of the consequences of transportation damage, disruption, and failure are presented in Table 38. This table is provided purely to illustrate potential impacts; it is not meant to imply that these impacts will definitively occur, nor is this list fully comprehensive of all potential consequences to all asset types.

Table 38. Illustrative Consequences of Transportation Asset Damage, Disruption, or Failure

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
Airports	City Services Human Health Historical, Tribal Cultural, and Archaeological Resources Natural Resources and the Environment	Brown Field Municipal Airport (KSDM) and Montgomery-Gibbs Executive Airport (KMYF) are the airports owned and operated by the City of San Diego. Both City-owned airports provide critical services, such as law enforcement, air ambulance, and fire-rescue operations. Both also serve as reliever airports for San Diego International Airport and provide flight training and cargo services. Brown Field Municipal Airport contains historical, tribal cultural, and archaeological resources, including the Alta School site and several building facilities within the Auxiliary Naval Air Station Brown Field Historic District. Damage to these structures could impact their ability to convey historical and cultural information and value (Consultation with City of San Diego Historic Preservation Planning, 2020). These airports also contain open space, vernal pools, and endangered species.
Bridges	City Services Human Health Social Equity Historical, Tribal Cultural, and Archaeological Resources	Bridges often have less redundancy than other parts of the transportation system, since there are limited crossings over bodies of water. Thus, failure could result in collapse of all or some portion of the transportation system (FHWA, 2011). Disruptions or delays could affect people going about their daily lives and reduce mobility of goods, resulting in economic losses (Pregnolato, Ford, Wilkinson, & Dawson, 2017). This could disrupt emergency response services if the capacity of certain routes (e.g., evacuation routes) becomes compromised. The Coast Walk Trail and Devil's Slide Footbridge, the First Avenue Bridge, the Georgia Street Bridge, the Quince Street Footbridge, and the Spruce Street Suspension Bridge are City-owned designated historical resources. Additionally, other bridges that are not currently designated may be eligible for designation pending evaluation. Damage to these structures could impact their ability to convey historical and cultural information and value.
Roadway Network (Major Arterials)	City Services Human Health Social Equity	Disruptions or delays could affect people going about their daily lives and reduce mobility of goods, resulting in economic losses (Pregnolato, Ford, Wilkinson, & Dawson, 2017). Also, roadway disruptions could disrupt emergency response services if the capacity of certain routes (e.g., evacuation routes) becomes compromised. There could be a risk of injury, depending on the type of damages. Communities of concern may have fewer mobility options to reach critical service, so they may be disproportionately affected by disruptions.

Storm Water Consequences

Storm water systems play a key role in reducing the risk of flooding. Because of this, impacts to this infrastructure could exacerbate damages due to climate change-related hazards. For example, flooding could be exacerbated if storm water systems become overwhelmed or blocked by debris. Damage, disruption, or failure of storm water systems would impact City services through responses to manage flood risk. Corrosion and pipe deterioration may occur faster under pipes exposed to more frequent and larger storm events.

Illustrative examples of the consequences of storm water system damage, disruption, and failure are presented in Table 39.

Table 39. Illustrative Consequences of Storm Water Asset Damage, Disruption, or Failure

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
Drain Pump Stations	City Services Human Health Social Equity	Pump stations remove storm water from areas that cannot be drained by gravity. Flooding could be exacerbated if the pumps fail, potentially resulting in significant damages. For example, road safety could be threatened if roads become flooded. Other transportation disruptions and potential traffic accidents could occur. Communities of concern may have fewer mobility options to reach critical service, so they may be disproportionately affected by disruptions.
Outfalls	City Services Human Health Natural Resources and Environment	If outfalls are inhibited, storm water could back up and exacerbate flooding. Reduced discharge capacity could cause flooding of adjoining areas and disrupt access to homes, jobs, and recreation areas (BCDC, 2019). This would require additional maintenance and response. Depending on the source and destination of the outfall, damage or failure could negatively affect water quality of surface waters. Water contamination has implications for human health and the environment.
Levees	City Services	The city's levees, which provide crucial floodwater protection,

	Human Health	are situated along the San Diego River south of Mission Bay and along the Tijuana River.[33] If they were to be compromised by climate hazards, then the area surrounding the levees may experience flooding. This could disrupt transportation, business, and pose a health and safety risk to the public.

Transportation and Storm Water Vulnerability to Coastal Hazards

Coastal hazards include sea level rise, storm surge, and erosion. Daily flooding was used to estimate exposure to chronic inundation and represents the extent of flooding that would occur at high tide on average each day under each sea level rise scenario. Storm surge flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm under each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

The City found that all transportation and storm water critical asset types except airports, which are not exposed, and levees, which received a low vulnerability score, are highly vulnerable to sea level rise and have medium to high vulnerability to storm surge with sea level rise. Bridges, major arterials, and outfalls show vulnerability to coastal erosion. All erosion scenarios assume 2.0 meters of sea level rise (which is the upper range for 2100).

The results of the vulnerability assessment of transportation and storm water critical asset types to coastal hazards are shown in Table 40, Table 41, and Table 42.

The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to coastal hazards. Table 44 provides the rationale for the sensitivity and adaptive capacity scores.

Table 40. Vulnerability of Transportation and Storm Water Critical Asset Types to Sea Level Rise

Sea Level Rise (SLR)	Airports[34]	Bridges	Major Arterials	Drain Pump Stations	Outfalls	Levees
Exposure	N/A	High	High	High	High	Low
Sensitivity	N/A	High	High	High	High	Medium
Adaptive Capacity	N/A	Medium	Medium	Low	Low	Medium
Vulnerability	N/A	High	High	High	High	Low

[33] At this time, analysis was only completed for the San Diego River Levee. The Tijuana River levee was not evaluated as part of the exposure assessment. However, the sensitivity and adaptive capacity narratives for the San Diego River levees would also apply to the Tijuana River levees.
[34] The Real Estate Assets Department (READ) manages the City-owned airports. All other transportation assets are managed by the Transportation and Storm Water Department (TSWD).

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scorin g methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 41. Vulnerability of Transportation and Storm Water Critical Asset Types to Storm Surge with Sea Level Rise (One Hundred-Year storm)

Storm Surge with SLR	Airports	Bridges	Major Arterials	Drain Pump Stations	Outfalls	Levees
Exposure	Not exposed	High	High	High	High	Low
Sensitivity	N/A	Medium	Medium	Medium	Medium	Low
Adaptive Capacity	N/A	Medium	Medium	Low	Low	Medium
Vulnerability	**N/A**	**Medium**	**Medium**	**High**	**High**	**Low**

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of t he timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scorin g methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 42. Vulnerability of Transportation and Storm Water Critical Asset Types to Coastal Erosion at Medium-High Risk Aversion Scenario of 2m of Sea Level Rise

Coastal Erosion	Airports	Bridges	Major Arterials	Drain Pump Stations	Outfalls	Levees
Exposure	Not exposed	High	Medium	Not exposed	High	Not exposed
Sensitivity	N/A	High	High	N/A	High	N/A
Adaptive Capacity	N/A	Low	Medium	N/A	Low	N/A
Vulnerability	**N/A**	**High**	**Medium**	**N/A**	**High**	**N/A**

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scorin g methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Transportation and Storm Water Exposure to Coastal Hazards

Sea Level Rise Projections for San Diego

2030: 0.25 m SLR

2050: 0.5 to 0.75 m SLR

2100: 1.0 to 2.0 m SLR

A small portion of the critical transportation assets may be exposed to sea level rise and storm surge with sea level rise, whereas a large percentage of storm water assets face exposure to coastal hazards (Figure 25, Figure 26). This exposure analysis was conducted by comparing the locations of assets, such as bridge approaches, to projected flooding with different levels of sea level rise and storm surge with sea level rise, to determine the assets' potential exposure. Information on the elevation of assets (such as bridges) would be necessary to determine whether they would be underwater given a certain height of sea level rise or storm surge.

Across all transportation assets, less than five percent may be exposed to sea level rise; however, there is local exposure in some coastal neighborhoods (Figure 25). According to institutional knowledge within the Transportation and Storm Water Department, only eight road locations have historically been subject to repeat tidal flooding. Of the transportation elements analyzed, major arterial segments showed the greatest exposure in the near term (thirty-two segments at .25 m in 2030). Over time, more significant portions of the major arterial network—up to 213 segments at 1.0 to 2.0 m (2100)—may be exposed to sea level rise. With .25 m sea level rise (2030), four bridges would face exposure to sea level rise; up to seven more becoming exposed by the end of the century (2.0 m sea level rise). Compared with transportation assets, a much larger proportion of storm water assets may be exposed to sea level rise. Seven percent of drain pump stations may be exposed starting at 0.25 m sea level rise (2030), and thirty-six to fifty-seven percent of drain pump stations may be exposed by 2100 (1.0 to 2.0 m sea level rise). Twenty-seven percent of outfalls may be exposed starting at 0.25 m sea level rise (2030), and thirty-nine to fifty-one percent of outfalls may be exposed by 2100 (1.0 to 2.0 m sea level rise).

Figure 24. A coastal storm water outfall in San Diego.

With storm surge and sea level rise scenarios, where sea level rise vulnerability is compounded by storm surge, assets become exposed across a broader spectrum of sea level rise ranges. Under these scenarios a few additional transportation assets face flooding but the proportion still stays below 5 percent, with a total of up to 323 major arterial road segments potentially exposed to a storm surge event in 2100 (2.0 m sea level rise) (Figure 26). Major arterial segments would be the most exposed with the addition of storm surge to sea level rise: 44 segments face projected exposure in 2030, increasing to 123 - 323 segments by 2100.

More storm water assets may also become exposed to inundation during a storm surge. Thirty-six percent of stations may be exposed starting at 0.25 meters (2030), and between forty-three and eighty-six percent of drain pump stations may face flooding from storm surge with sea level rise in 2100. Similar to drain pump stations, thirty-six percent of outfalls may be exposed to storm surge with sea level rise starting at 0.25 meters of sea level rise (2030), and fifty to fifty-nine percent may be exposed by 2100.

Among the transportation assets, bridges are not exposed to cliff erosion, and there is a single major arterial segment that may be exposed (Figure 27). Among the storm water assets, outfalls may be more exposed than drain pump stations to cliff erosion: fifteen percent of outfalls face exposure. As Figure 28 shows, a single bridge and major arterial segment face exposure to beach erosion. Similar to cliff erosion, outfalls face the greatest proportion exposure to beach erosion at eight percent. No drain pump stations are expected to be exposed to erosion.

While the City-owned airports (Brown Field Municipal Airport and Montgomery-Gibbs Executive Airport) are inland and therefore not exposed to coastal hazards, both airports serve as reliever airports for smaller aircraft that would otherwise be served by San Diego International Airport, which is coastal. Impacts to San Diego International Airport could have cascading effects, such as potential rerouting of aircraft to City-owned airports (Consultation with City of San Diego Real Estate Assets Department, 2019). San Diego International Airport has prepared its own Climate Resilience Plan, which focuses on sea level rise, precipitation patterns, and extreme heat (San Diego International Airport, 2019).

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the coastal hazard scenarios.

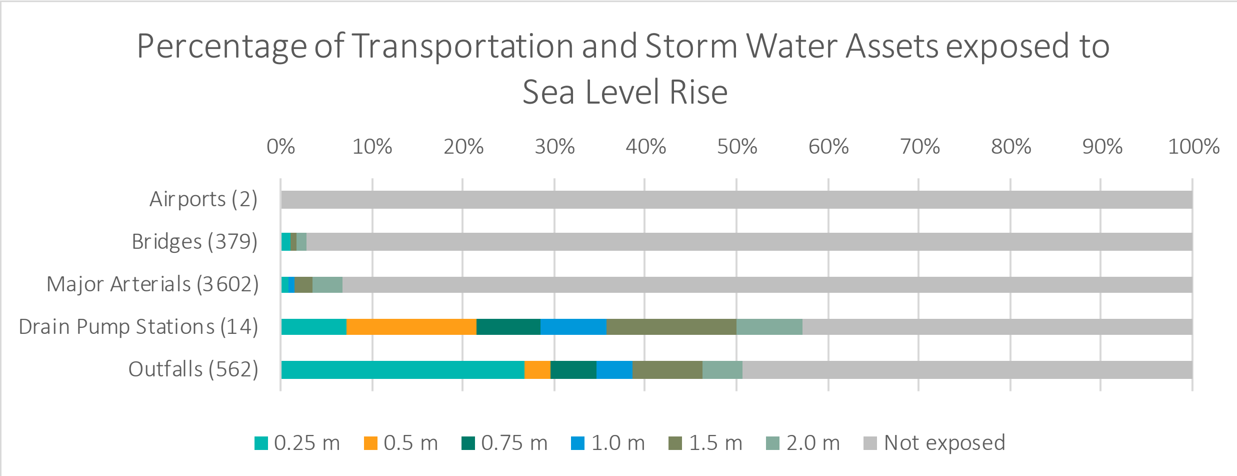

Figure 25. Transportation and storm water critical assets exposed to sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario.

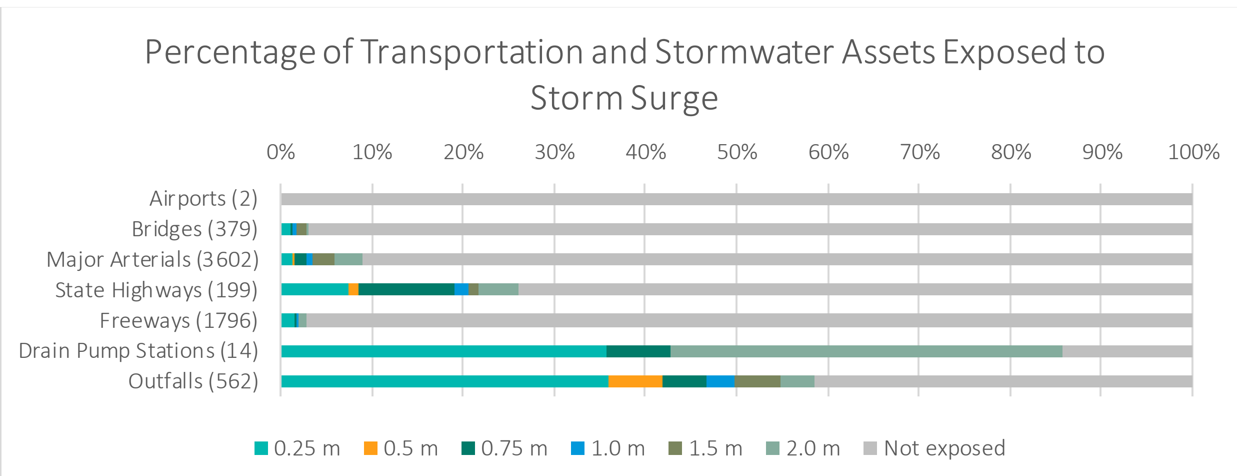

Figure 26. Transportation and storm water critical assets exposed to storm surge with sea level rise; this includes the 100-year storm on top of sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario. Assets would be exposed to storm surge prior to being exposed to average daily flooding, so more assets in this graph tend to be exposed under lower sea level rise amounts.

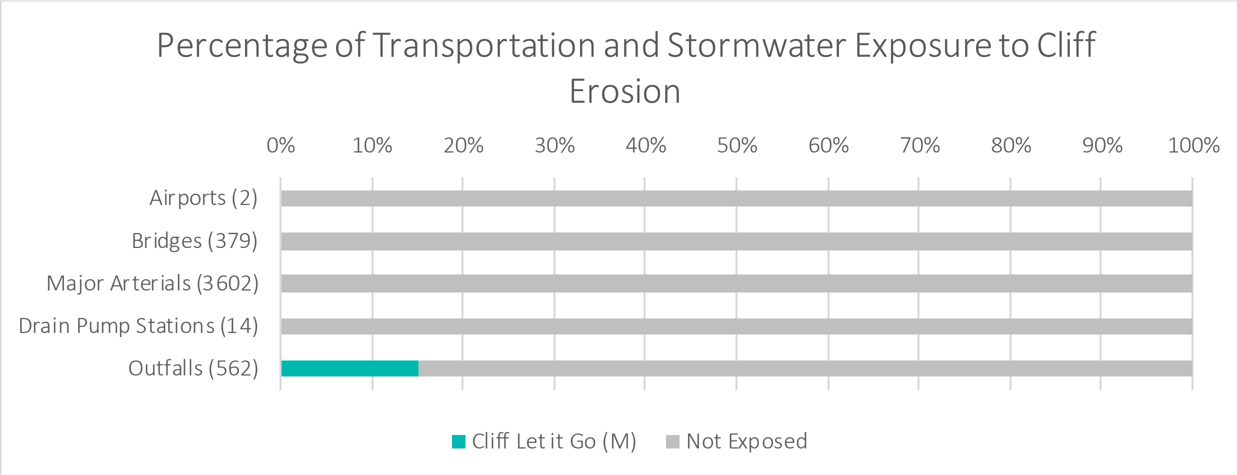

Figure 27. Transportation and storm water critical assets exposed to cliff erosion. The value after each asset name indicates the asset count. "Cliff let it go" represents the number of assets exposed to flooding if the City does not implement coastal armoring and allows cliff retreat and erosion.

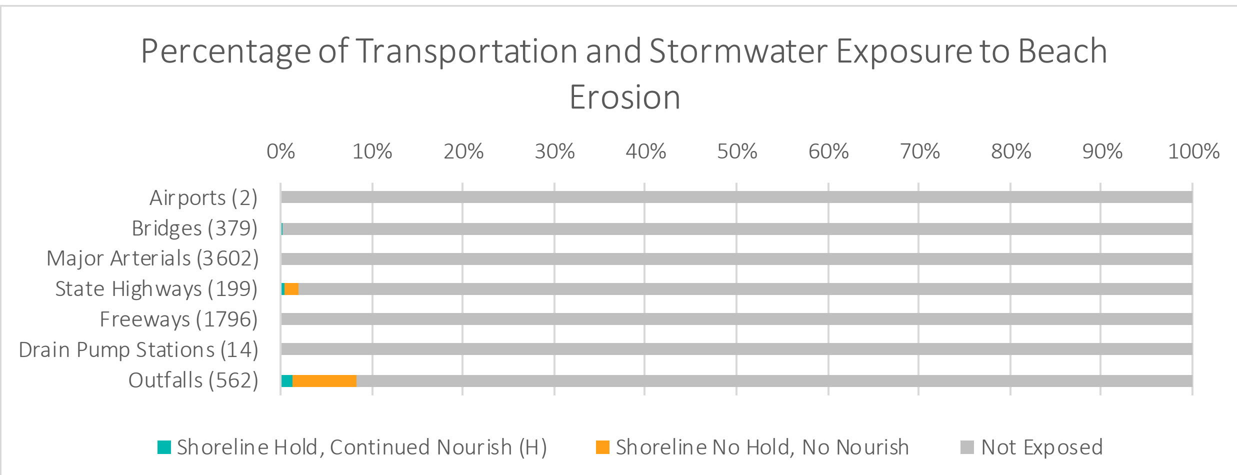

Figure 28. Transportation and storm water critical assets exposed to beach erosion. The value after each asset name indicates the asset count. "Shoreline Hold, Continued Nourish" represents the number of assets exposed to flooding if the City continues beach nourishment and sea wall repair, while "Shoreline No Hold, No Nourish" represents the number of assets exposed if the City were to stop beach nourishment and seawall repair.

Levee Exposure to Coastal Hazards

Estimates of levee exposure to sea level rise were based on the City's internal calculations and scoring, which employ a different methodology from that used for the other asset types in this vulnerability assessment. The City determined the minimum elevation of each levee, then compared this elevation to projected sea level rise. The levees were determined to be exposed to sea level rise when the projected sea level exceeded the minimum levee elevation. The City incorporated storm surge projections by adding the historical National Oceanic and Atmospheric Administration's (NOAA) Annual Exceedance Probability Curves for San Diego Bay (0.73 meters [2.40 feet] above Mean Higher High Water for the 100-year storm) to projected sea levels (Table 43).[35]

Table 43. Exposure of City of San Diego Levees to Sea Level Rise in 2030, 2050, and 2100 based on low, medium-high, and extreme risk scenarios. All units are feet.

Year	Present-Day Tidal Datum		Sea Level Rise Scenario			Levee Elevation Relative to Sea Level Rise			Levee Elevation Relative to Storm Surge with SLR		
	Levee Elevation	Mean Higher High-Water Elevation above MSL	Low	Medium - High	Extreme	Low	Medium - High	Extreme	Low	Medium - High	Extreme
2030	9.8	2.8	0.8	1.1	1.5	6.2	5.9	5.5	3.8	3.5	3.1
2030	11.6	2.8	0.8	1.1	1.5	8.0	7.7	7.3	5.6	5.3	4.9
2050	9.8	2.8	1.2	2.0	2.8	5.8	5.0	4.2	3.4	2.6	1.8
2050	11.6	2.8	1.2	2.0	2.8	7.6	6.8	6.0	5.2	4.4	3.6
2100	9.8	2.8	3.6	7.0	10.2	3.4	0.0	**-3.2**	1.0	**-2.4**	**-5.6**
2100	11.6	2.8	3.6	7.0	10.2	5.2	1.8	**-1.4**	2.8	**-.06**	**-3.8**

The minimum elevations for the three City levees along the San Diego River are 9.8 feet, 11.6 feet, and 11.6 feet.

None of the three City levees along the San Diego River would experience overtopping until 10.2 feet of sea level rise (which the California Coastal Commission has categorized as an extreme risk aversion scenario for 2100) (Consultation with City of San Diego Transportation and Storm Water Department, 2020). Exposure at 10.2 feet (3.1 meters) of sea level rise corresponds to the vulnerability assessment's low exposure score since it is not projected to occur until late in the century.

Using 2.4 feet of storm surge based on NOAA's tidal datum, the levees are projected to be exposed to sea level rise with storm surge—beginning with the medium-high risk aversion projection for 2100, which equates to 7 feet (or 2.1 meters), which also results in a low exposure score.

It is possible that sea level rise inundation could flow from the non-river side, and the City should consider how sea level rise might impact the area surrounding the levees. This is a potential area for future modeling and research.

[35] https://tidesandcurrents.noaa.gov/est/curves.shtml?stnid=9410170

Transportation and Storm Water Sensitivity and Adaptive Capacity to Coastal Hazards

Based on the exposure analysis, the City assessed the sensitivity and adaptive capacity of all transportation and storm water critical asset types except airports to coastal hazards. The results of this analysis are shown in Table 44 below.

Table 44. Sensitivity and Adaptive Capacity of Transportation and Storm Water Critical Asset Types to Coastal Hazards

Bridges	
SLR Sensitivity: High Daily inundation could cause structural damage to assets and cut off access from flooded routes.	*SLR Adaptive Capacity: Medium* There is relatively low redundancy in the bridge network. Daily flooding could require the creation of alternate routes outside of inundation zones. Currently there is no routine maintenance performed on bridges, and no routine funds allocated for maintenance and repair. However, if it is a priority repair/safety related, the City addresses those needs. State funds could be applied for to address issues that Caltrans finds during its inspections and are categorized as Capital Improvement Plan work. Currently, there is no State or Federal grant program for routine bridge maintenance. (Consultation with City of San Diego Transportation and Storm Water Department (TSWD), 2019).
Storm Surge with SLR Sensitivity: Medium Sea level rise is projected to increase the frequency and baseline water level of extreme storms, which may exceed design standards for bridges. Storm surge could stress bridges via erosion and scour, and by washing debris into bridges (FHWA, 2014). Typically, bridge and roadway drainage design standards are for the historical 100-year storm. For bridges that cross over a channel or river rather than a roadway, the design standard may change to suit needs (e.g., West Mission Bay Drive is designed to withstand a 500-year tsunami). A majority of bridges in San Diego have gone through major rehabilitation improvements and have been seismically retrofitted (City of San Diego, 2019).	*Storm Surge with SLR Adaptive Capacity: Medium* There is limited redundancy in the bridge network. Currently there is no routine maintenance performed on bridges, and no routine funds allocated for maintenance and repair. However, if it is a priority repair, safety related, the City addresses those needs. State funds could be applied for to address issues that Caltrans finds during its inspections and are categorized as Capital Improvement Plan work, though this is a limited pool that may only cover one to two bridges every few years (Consultation with City of San Diego TSWD, 2019).
Coastal Erosion Sensitivity: High Roads and bridges are highly sensitive to erosion.	*Coastal Erosion Adaptive Capacity: Low* There is limited redundancy in the bridge

If major routes become eroded, new routes should be created (ICLEI, 2017) (Consultation with City of San Diego TSWD, 2019).	network. Currently there is no routine maintenance performed on bridges, and no routine funds allocated for maintenance and repair. However, if it is a priority repair, safety related, the City addresses those needs. State funds could be applied for to address issues that Caltrans finds during its inspections and are categorized as Capital Improvement Plan work, though this is a limited pool that may only cover one to two bridges every few years (Consultation with City of San Diego TSWD, 2019).
Major Arterials	
SLR Sensitivity: High Daily inundation could cause structural damage to the road subgrade and cut off access from flooded routes.	*SLR Adaptive Capacity:* Medium The roadway network in the coastal zone has high redundancy; however, policy and planning decisions are needed for long-term solutions (Consultation with City of San Diego TSWD, 2019).
Storm Surge with SLR Sensitivity: Medium Periodic flooding of major arterials could cause significant disruptions in the transportation system and could damage roads in the long term, especially damaging the subgrade layers (City of San Diego, 2019).	*Storm Surge with SLR Adaptive Capacity:* Medium There is significant redundancy in the roadway network and the Transportation and Storm Water Department could prepare for periodic flooding by setting up pumps, building berms, and closing flood gates, as well as providing anticipated areas of road closures (Consultation with City of San Diego TSWD, 2019). Longer-term adaptation is more difficult. For example, porous pavement is not an option for major roads (Consultation with City of San Diego TSWD, 2019). Repairs resulting from previous storms have been relatively low-cost (FEMA, 2017; City of San Diego, 2017b).
Coastal Erosion Sensitivity: High Roads are highly sensitive to erosion and have already begun to suffer the impacts. If major routes become eroded, new routes should be created (ICLEI, 2017).	*Coastal Erosion Adaptive Capacity:* Medium Permanent impacts from erosion pose a more significant challenge for adaptation (ICLEI, 2017). However, there is significant redundancy in the roadway network. Rerouting traffic through a detour or temporarily limiting service on affected roads would affect fewer travelers than on state-owned routes (e.g., state highways and freeways).
Drain Pump Stations	

SLR Sensitivity: High Storm water assets may become inundated from sea level rise and higher groundwater levels. Inundation of the system could cause the pumps to continuously run without making progress, resulting in pump failure and burnout.	*SLR Adaptive Capacity: Low* It is relatively difficult to adapt drain pump stations (by increasing elevation, adding backflow valves, and/or installing additional pumps). There are spatial and topographical constraints to elevating drain pump stations, which add to the time and cost of required engineering. There are also the spatial constraints of other existing structures and easement widths when considering the relocation of a station. As of 2019, the cost to replace one drain pump station could be between $4.5 and $6 million (Consultation with City of San Diego TSWD, 2019). Pumps may have to be reconfigured for a greater strength or capacity.
Storm Surge with SLR Sensitivity: Medium Storm water assets may become inundated from floods and higher groundwater levels. Periodic flooding from storm surge, however, would be less detrimental than chronic inundation.	*Storm Surge with SLR Adaptive Capacity: Low* It is relatively difficult to adapt drain pump stations (by increasing elevation, adding backflow valves, and/or installing additional pumps). There are spatial and topographical constraints to elevating drain pump stations, which add to the time and cost of required engineering. There are also the spatial constraints of other existing structures and easement widths when considering the relocation of a station (Consultation with City of San Diego TSWD, 2019). As of 2019, the cost to replace one drain pump station could be between $4.5 and $6 million (Consultation with City of San Diego TSWD, 2019).
Coastal Erosion Sensitivity: Not exposed	*Coastal Erosion Adaptive Capacity: Not exposed*
Outfalls	
SLR Sensitivity: High There are outfalls with elevation that would be chronically inundated/submerged, resulting in poor drainage and/or backflow of water. The storm water system may become inundated from floods and higher groundwater levels, and a redesign would be necessary to accommodate changing sea level elevations (e.g., outfall elevation).	*SLR Adaptive Capacity: Low* It is relatively difficult to adapt outfalls (by increasing elevation and/or adding backflow valves). There are spatial and topographical constraints to elevating outfall pipes, which add to the time and cost of required engineering. There are also the spatial constraints of other existing structures and easement widths when considering the relocation of an outfall (Consultation with City of San Diego TSWD, 2019). As of 2019, the cost to replace one storm water

	outfall could be between $1.35 and $2 million (Consultation with City of San Diego TSWD, 2019).
Storm Surge with SLR Sensitivity: Medium Storm surge may temporarily impede the effectiveness of the storm water system/outfalls by preventing storm water drainage, especially for gravity-fed portions of the system.	*Storm Surge with SLR Adaptive Capacity: Low* It is relatively difficult to adapt outfalls (by increasing elevation and/or adding backflow valves). There are spatial and topographical constraints to elevating outfall pipes, which add to the time and cost of required engineering. There are also the spatial constraints of other existing structures and easement widths when considering the relocation of an outfall (Consultation with City of San Diego TSWD, 2019). As of 2019, the cost to replace one storm water outfall could be between $1.35 and $2 million (Consultation with City of San Diego TSWD, 2019).
Coastal Erosion Sensitivity: High Erosion could compromise the functionality of the system.	*Coastal Erosion Adaptive Capacity: Low* It is relatively difficult to adapt outfalls as there are the spatial constraints of other existing structures and easement widths when considering the relocation of an outfall (Consultation with City of San Diego TSWD, 2019). As of 2019, the cost to replace one storm water outfall could be between $1.35 and $2 million (Consultation with City of San Diego TSWD, 2019).
Levees	
SLR Sensitivity: Medium By their nature, levees are meant to endure daily exposure to water and are designed with flooding in mind. However, daily overtopping would render the levees ineffective.	*SLR Adaptive Capacity: Medium* Increasing the height of the levees is an option; however, doing so generally requires federal approval and significant resources.
Storm Surge with SLR Sensitivity: Low By their nature, levees are meant to endure daily exposure to water and are designed with flooding in mind.	*Storm Surge with SLR Adaptive Capacity: Medium* Increasing the height of the levees is an option; however, doing so generally requires federal approval and significant funding.
Coastal Erosion Sensitivity: Not exposed	*Coastal Erosion Adaptive Capacity: Not exposed*

Transportation and Storm Water Vulnerability to Precipitation-driven Flooding

The City found that all transportation and storm water critical asset types except airports show medium to high vulnerability to precipitation-driven flooding. Those showing high vulnerability include drain pump stations and outfalls. The high outfall vulnerability indicates a broader vulnerability of the storm water system, which also includes storm water conveyance pipes and channels. These pipes and channels were not formally assessed, but are considered as part of the storm water system when discussing sensitivity and adaptive capacity in Table 46 below (see the outfalls portions of the table). When considering updates to the storm water system to address climate change vulnerabilities, the complete storm water system needs to be taken into consideration. For the system to function, the entire interconnected system must be resilient.

The results of the vulnerability assessment of transportation and storm water critical asset types to precipitation-driven flooding are shown in Table 45. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to precipitation-driven flooding. Table 46 provides the rationale for the sensitivity and adaptive capacity scores.

Table 45. Vulnerability of Transportation and Storm Water Critical Asset Types to Precipitation-driven Flooding

	Airports [36]	Bridges	Major Arterials	Drain Pump Stations	Outfalls	Levees
Exposure	Low	High	High	High	High	High
Sensitivity	Medium	Medium	Medium	Medium	High	Low
Adaptive Capacity	Medium	Medium	Medium	Low	Medium	Medium
Vulnerability	Low	Medium	Medium	High	High	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Transportation and Storm Water Exposure to Precipitation-driven Flooding

All transportation asset types except airports have assets within the 100- and 500-year floodplains, though these exposed assets represent a relatively small proportion of total transportation assets. Storm water assets face greater proportional exposure to precipitation-driven flooding than do transportation assets (Figure 31). About twelve percent of major arterial segments may be exposed to precipitation-driven flooding, and about half of these lie in the 100-year floodplain. Bridges may be less exposed to

[36] The Real Estate Assets Department (READ) manages the City-owned airports. All other transportation assets are managed by the Transportation and Storm Water Department (TSWD).

precipitation-driven flooding, but most of the assets that are exposed lie in the 100-year floodplain (which carries a higher exposure score).

According to institutional knowledge of the Transportation and Storm Water Department, forty road locations have historically been subject to precipitation-driven flooding.[37] These locations are largely local roads, including roads in downtown San Diego (Figure 29) and near Mission Bay (Figure 30). Under a climate change scenario, the quantity of locations subject to future flooding is likely to increase.

[37] The locations where roadways experience repeated flooding were identified based on the knowledge and expertise of the transportation department. While this testimony is critical institutional knowledge, no easily accessible documentation is available to support this information. This could mean that certain locations are more memorable, and some sites may be missed, or the damages could be misrepresented. Incident reports or other documentation of damages would help corroborate the findings and provide more robust data on the frequency or duration of flooding.

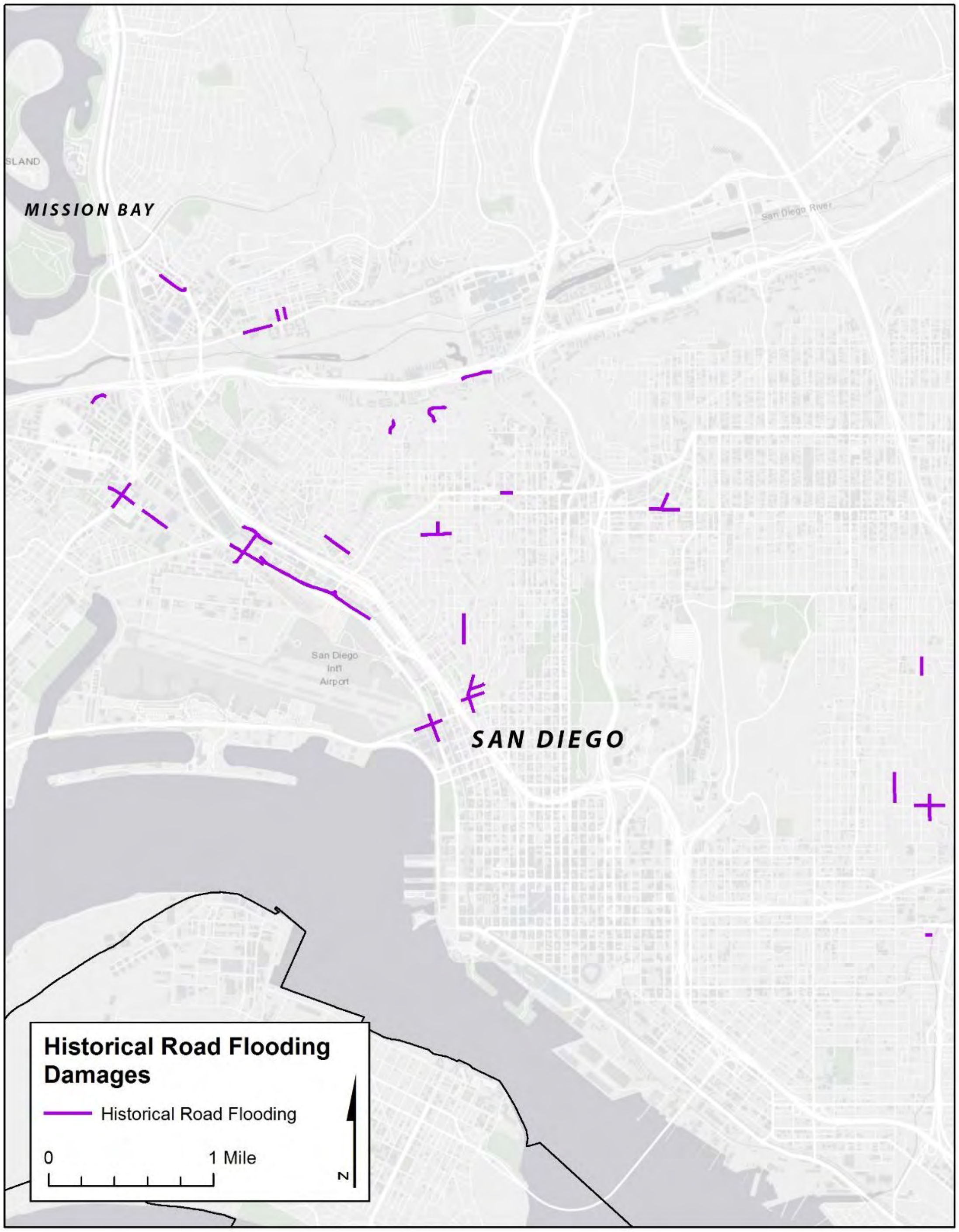

Figure 29. Areas of historical road flooding damages in downtown San Diego. Data courtesy of Street Division.

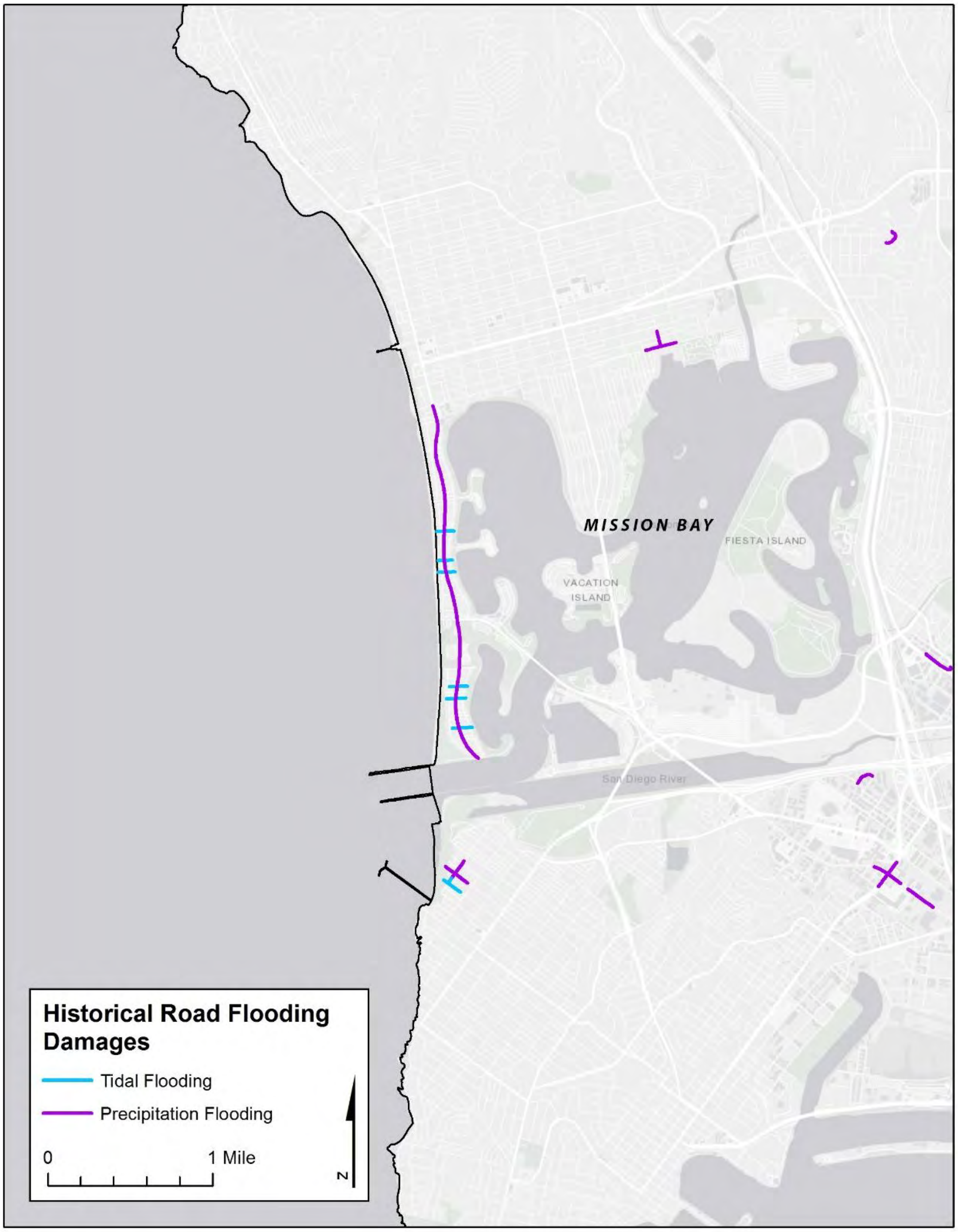

Figure 30. Locations of historical road flooding damage in the City of San Diego Mission Bay area. Data courtesy of Street Division.

One location that has historically flooded is along Aero Drive near the Montgomery-Gibbs Executive Airport; however, the airport itself is not exposed to the 100- or 500-year floodplains. As Aero Drive is the only route available to reach the main entrance to Montgomery-Gibbs Executive Airport, flooding of this road would cut off access to portions of the airport. Historical flooding in this area could be attributed to the hard pan surface of the soil underneath the airport, which has previously resulted in flooding and the formation of vernal pools during heavy rain events.[38] Additionally, institutional knowledge from the airport team within the Real Estate Assets Department (READ) indicates that the City airports have experienced pooling during particularly heavy rain years, which could lead to complications for aviation equipment. As such, airports were included as "exposed" for this vulnerability assessment, although they are not represented as such in Figure 31 below.

Both storm water asset types—drain pump stations and outfalls—have about thirty-five percent of their assets lying in the 100-year floodplain. Drain pump stations have roughly an additional ten percent of assets lying in the 500-year floodplain, while outfalls have an additional fifteen percent in the 500-year floodplain.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to precipitation-driven flooding.

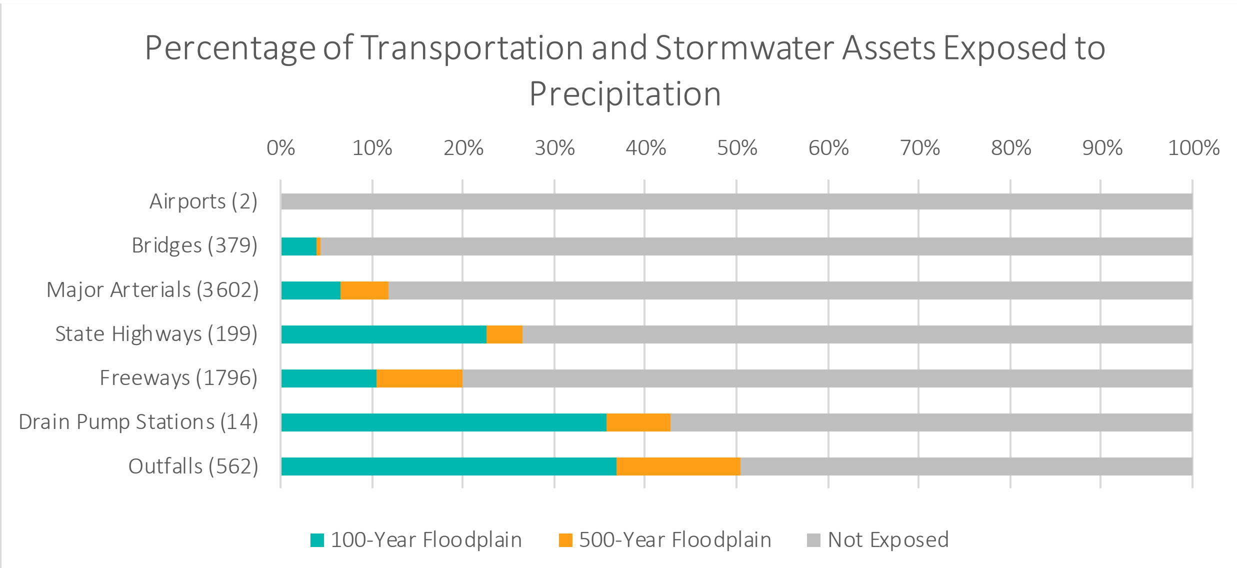

Figure 31. Transportation and storm water critical assets exposed to precipitation. The value after each asset name indicates the asset count. All assets in the 100-year floodplain also lie in the 500-year floodplain; the orange colored bar for the 500-year floodplain shows assets that are outside the 100-year floodplain but experience flooding under more extreme precipitation events.

Levee Exposure to Precipitation-driven Flooding

The southern bank of the San Diego River levee system is not vulnerable to precipitation-driven flooding, as infrastructure developed after the levees were put in place (including Caltrans-built Interstate 8) was

[38] A vernal pool, sometimes called an "ephemeral pool" due to its impermanence, is a small pond or lake formed by seasonal rains. These areas may fill up or dry out multiple times over the course of a season, depending on precipitation and drought patterns.

built higher than the FEMA floodplain level (Consultation with City of San Diego Transportation and Storm Water Department, 2020).

The northern bank is at a lower elevation and may be exposed to potential precipitation-driven overtopping as storm events increase in intensity and as sea levels rise.

Transportation and Storm Water Sensitivity and Adaptive Capacity to Precipitation

Based on the exposure analysis, the City assessed the sensitivity and adaptive capacity of all transportation and storm water critical asset types to precipitation. The results of this analysis are shown in Table 46 below.

Table 46. Sensitivity and Adaptive Capacity of Transportation and Storm Water Critical Asset Types to Precipitation-driven Flooding

Airports	
Precipitation Sensitivity Rating: *Medium* The soil underneath the airport is a hard pan, which does not allow for typical water absorption. This could result in vernal pool formation. In previous heavy rain events, pools have caused problems with aviation equipment (e.g., radar technology that bounces off the ground experiences interference from pooling; standing water may make it unsafe to operate aircraft). Heavy precipitation and flooding could also lead to erosion, potholes, and sink holes on taxiways. When rain causes flooding, the airports have to close off access to unpaved areas such as the perimeter road to avoid impacts to environmental resources. Flooding could also prevent emergency access to the area. In addition, mowing crews may not be able to properly maintain airfields during wet conditions (Consultation with City of San Diego Real Estate Assets Department, 2019).	*Precipitation Adaptive Capacity Rating:* *Medium* Airport staff could take some preemptive measures to prepare for certain impacts of precipitation-based flooding (e.g., mowing in advance of a forecasted storm). Airports could also implement runway grooving techniques, which provides skid resistance and prevents hydroplaning during wet weather (FAA, 2007). The airports have an asphalt rehabilitation program and schedule in place to help maintain taxiways and mitigate long-term damage. Green infrastructure measures that are well-suited to catching and holding storm water (and therefore mitigating flooding) are less suitable to airports, as bird populations should be discouraged from establishing at airports or else they are at risk of being struck by planes and possibly interrupting flight operations and/or damaging equipment.
Bridges	
Precipitation Sensitivity Rating: *Medium* Increased precipitation could lead to flooding and scour and could wash debris into bridges, potentially resulting in failure (FHWA, 2012). A majority of bridges in San Diego have gone through major rehabilitation improvements and have been seismically retrofitted. (City of San	*Precipitation Adaptive Capacity Rating:* *Medium* There is limited redundancy in the bridge network. Currently there is no routine maintenance performed on bridges, and no routine funds allocated for maintenance and repair. However, if it is a priority repair, safety related, the City addresses those needs (Consultation with City of San Diego TSWD, 2019). Before every storm, the City prepares for recovery by

Diego, 2019). Typically, bridge and roadway drainage design standards are for a 100-year storm. For bridges that cross over a channel or river rather than a roadway, the design standard may change to suit needs (e.g., West Mission Bay Drive is designed to withstand a 500-year tsunami).	organizing a fleet of vehicles essential to performing tasks such as clearing logjams, etc. The City removes logs and debris using cranes after flooding/storm events.
Major Arterials	
Precipitation Sensitivity Rating: Medium Periodic flooding of major arterials could cause significant disruptions in the transportation system and could damage roads in the long term, especially damaging the subgrade layers (City of San Diego, 2019).	*Precipitation Adaptive Capacity Rating: Medium* There is significant redundancy in the roadway network and the Transportation and Storm Water Department could prepare for periodic flooding by setting up pumps, building berms, and closing flood gates, as well as providing anticipated areas of road closures (Consultation with City of San Diego TSWD, 2019). Longer-term adaptation is more difficult. For example, porous pavement is not an option for major roads (Consultation with City of San Diego TSWD, 2019). Repairs resulting from previous storms have been relatively low-cost (FEMA, 2017; City of San Diego, 2017b).
Drain Pump Stations	
Precipitation Sensitivity Rating: Medium Drain pump stations may become overwhelmed if the volume of precipitation exceeds their capacity. However, the last time that significant damage occurred due to a pump station being underwater, multiple factors converged to cause the damage, such as debris, rain, and high tide (Consultation with City of San Diego TSWD, 2019).	*Precipitation Adaptive Capacity Rating: Low* It is relatively difficult to adapt drain pump stations (by increasing elevation, adding backflow valves, and/or installing additional pumps). There are spatial and topographical constraints to elevating drain pump stations, which add to the time and cost of required engineering. There are also the spatial constraints of other existing structures and easement widths when considering the relocation of a station (Consultation with City of San Diego TSWD, 2019). As of 2019, the cost to replace one drain pump station could be between $4.5 and $6 million (Consultation with City of San Diego TSWD, 2019).
Outfalls	

Precipitation Sensitivity Rating: High The intensity and duration of the rain determines the amount of damage experienced. Storm water systems (which include outfalls as well as pipes and channels) are typically able to keep up with rain events, but rapid high-volume peak flows could quickly overwhelm the drainage system. In general, storm drain conveyance systems are designed for 100-year storms per the Drainage Design Manual. This means that these systems are equipped to handle current 100-year storms but may need to be upgraded if the 100-year storm is projected to become more intense or if the systems are within the 500-year floodplain (Consultation with City of San Diego TSWD, 2019). The age of the overall storm drain system may require system upgrades to address increased precipitation (Consultation with City of San Diego TSWD, 2019).	*Precipitation Adaptive Capacity Rating: Medium* Adding capacity (e.g., to deal with more intense storms and higher volumes of precipitation) is difficult when the asset in question would require additional area in a location constrained by existing structures and/or easement widths. As of 2019, the cost to replace one storm water outfall could be between $1.35 and $2 million. This cost does not include updates to the connected storm water conveyance system (e.g., pipes and channels). Storm water pipes and channels are necessary for overall system functioning and would also be in need of resilience upgrades to deal with more intense storms and higher volumes of storm water (Consultation with City of San Diego TSWD, 2019).
Levees	
Precipitation Sensitivity Rating: Low By their nature, levees are meant to endure daily exposure to water and are designed with flooding in mind.	*Precipitation Adaptive Capacity Rating: Medium* Increasing the height of the levees is an option; however, doing so generally requires federal approval and significant funding.

Transportation and Storm Water Vulnerability to Heat

The City found that all transportation and storm water critical asset types face exposure to heat, though drain pump stations' and levees' low exposure indicates nearly negligible vulnerability as areas with low urban heat island scores are expected to experience extreme heat events less frequently than areas with higher scores.

The results of the vulnerability assessment of transportation and storm water critical asset types to heat are shown in Table 47. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to heat. Table 48 provides the rationale for the sensitivity and adaptive capacity scores.

Table 47. Vulnerability of Transportation and Storm Water Critical Asset Types to Heat

	Airports [39]	Bridges	Major Arterials	Drain Pump Stations	Outfalls	Levees
Exposure	Medium	High	High	Low	High	Low
Sensitivity	Medium	Low	Low	Low	Low	Low
Adaptive Capacity	Medium	Medium	High	High	High	High
Vulnerability	Medium	Medium	Medium	Low	Medium	Low

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Transportation and Storm Water Exposure to Heat

The heat island scenarios are represented as zones with scores of 0 to 100+, with higher scores denoting hotter areas (CalEPA, 2019).[40] A score of zero indicates that there is no difference in temperature over time between an urban Census tract and nearby upwind rural reference points. A score of 100 indicates that there is a difference of 7.5 degrees Fahrenheit (approx. 4.2 degrees Celsius) between these tracts over 24 hours.

> In San Diego, coastal areas are relatively cooler than inland areas due to the moderating impacts of the ocean and offshore winds. This coastal effect dominates the urban heat island effect in the City.

Many transportation and storm water critical assets face low exposure to extreme heat (Figure 32).

Major arterial segments face the highest relative exposure to the higher set of potential temperatures compared to other transportation asset types, including over ten percent of major arterials that may be exposed at the 100+ heat index range.[41] Over half of bridges may be exposed at the 20+ heat index range. Both Montgomery-Gibb's Executive Airport and Brown Field Municipal Airport face exposure to heat, with Montgomery-Gibbs Executive Airport falling in the 40 to 60

[39] The Real Estate Assets Department (READ) manages the City-owned airports. All other transportation assets are managed by the Transportation and Storm Water Department (TSWD).

[40] The urban heat island index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period. To estimate the total number of degrees Fahrenheit per day, divide the Index by 24 hours and multiply by 1.8 degrees. Higher scores denote hotter areas.

[41] The major arterial asset type was assessed at the County level for exposure to heat, which included a total of 8,089 major arterial segments (exposed and un-exposed together). There are 3,602 major arterial segments in the City; only these segments were analyzed for the other hazards as the spatial analysis for other hazards was limited to the City boundary.

heat index range and Brown Field Municipal Airport falling in the 20 to 40 heat index range. For all asset types, assets exposed to the 0 to 20 heat index range (relatively low exposure) make up the largest portion of exposed assets.

Most storm water assets may be exposed to heat ranges which do not denote frequent high temperatures; all drain pump stations may be exposed to heat at the 0 to 20 heat index range. Most (over seventy percent) outfalls may be exposed to heat at the 0 to 20 heat level range. Only one outfall may be exposed at the 80 to 100 range.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the heat levels.

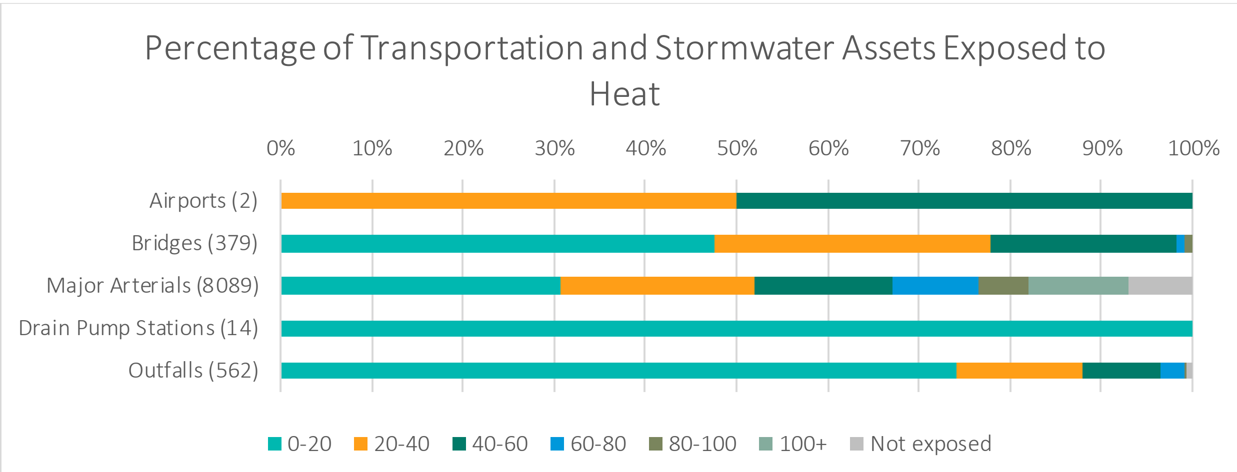

Figure 32. Transportation and storm water critical assets exposed to extreme heat. The value after each asset name indicates the asset count. The colored bars represent exposure to different ranges in the UHI index, with higher UHI values denoting hotter areas and therefore increased exposure to heat.

Levee Exposure to Heat

The San Diego River south bank levee is within the 0 to 20 UHI zone, with the westernmost portion (coastal) having a 5.8 degree-hour day and the easternmost portion (inland) having a 14.1 degree-hour day.

Transportation and Storm Water Sensitivity and Adaptive Capacity to Heat

Based on the exposure analysis, the City assessed the sensitivity and adaptive capacity of all transportation and storm water critical asset types to heat. The results of this analysis are presented in Table 48.

Table 48. Sensitivity and Adaptive Capacity of Transportation and Storm Water Critical Asset Types to Heat

Airports	
Heat Sensitivity Rating: Medium	*Heat Adaptive Capacity Rating: Medium*
Airport runways may experience road softening or buckling from high temperatures, which could affect planes' ability to take off and land.	Airports could implement high heat day rules (e.g., starting outdoor work earlier and rotating shifts) to protect crews while ensuring that

Additionally, crews may not be able to maintain airfields (e.g., by mowing) during high heat conditions, as outdoor physical labor in high heat can lead to heat illness. This has potential implications for the efficiency of air transportation. Hot air is less dense, which lowers an aircraft's ability to generate lift. In extreme heat conditions, some aircraft may lose the ability to take off or land until temperatures decrease (Federal Aviation Administration, 2008).	outdoor work could be accomplished. In addition, airports could issue extreme heat advisories to pilots and recommend they fly earlier or later in the day.
Bridges	
Heat Sensitivity Rating: Low Bridges may experience pavement thermal expansion, which could increase rates of deterioration (NRC, 2008).	*Heat Adaptive Capacity Rating:* Medium There is limited redundancy in the bridge system. Currently there is no routine maintenance performed on bridges, and no routine funds allocated for maintenance and repair. However, if it is a priority repair, safety related, the City addresses those needs (Consultation with City of San Diego TSWD, 2019).
Major Arterials	
Heat Sensitivity Rating: Low Asphalt pavement may crack, warp, soften, and/or buckle. Asphalt may bleed from old pavements (Mills & Andrey, 2002). Concrete may heave at joints (Heitzman, 2010).	*Heat Adaptive Capacity Rating:* High Asphalt is milled and replaced on a relatively frequent cycle (about twenty years), which allows for pavement mixes that are less susceptible to heat impacts to be used in the future (U.S. DOT, 2018).
Drain Pump Stations	
Heat Sensitivity Rating: Low Heat is not expected to significantly impact drain pump stations, unless extreme heat leads to power outages. In such a case, service could be temporarily interrupted.	*Heat Adaptive Capacity Rating:* High Backup (diesel) pumps can be moved to affected facilities in the event of a power outage (City of San Diego, PUD 2019).
Outfalls	
Heat Sensitivity Rating: Low Outfalls are not anticipated to be sensitive to heat.	*Heat Adaptive Capacity Rating:* High Adaptation of outfalls to heat is likely not necessary.
Levees	
Heat Sensitivity Rating: Low Generally, there is little impact that heat could pose to earthen levees.	*Heat Adaptive Capacity Rating:* High Adaptation of levees to heat is likely not

	necessary.

Transportation and Storm Water Vulnerability to Wildfires

The City found that all transportation and storm water critical asset types are highly vulnerable to wildfire except for outfalls and levees, which show medium vulnerability to wildfire.

The results of the vulnerability assessment of transportation and storm water critical asset types to wildfire are shown in Table 49. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to wildfire. Table 50 provides the rationale for the sensitivity and adaptive capacity scores.

Table 49. Vulnerability of Transportation and Storm Water Critical Asset Types to Wildfire

	Airports[42]	Bridges	Major Arterials	Drain Pump Stations	Outfalls	Levees
Exposure	High	High	High	High	High	High
Sensitivity	High	High	High	High	Medium	Medium
Adaptive Capacity	Medium	High	High	Medium	Medium	High
Vulnerability	High	High	High	High	Medium	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Transportation and Storm Water Exposure to Wildfire

All transportation and storm water critical asset types face exposure to wildfire (Figure 33). Of the exposed assets, most face high exposure; this includes 1 of the airports, 186 bridges, 1,048 major arterial segments, 3 storm water drain pump stations, and 163 storm water outfalls.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the fire hazard zones.

Wildfire Hazard Zones for San Diego

High: Native vegetation and 100-foot setback zones

Medium: 300-foot setback zone

Low: Fire hazard zone outside native vegetation zone and setbacks

[42] The Real Estate Assets Department (READ) manages the City-owned airports. All other transportation assets are managed by the Transportation and Storm Water Department (TSWD).

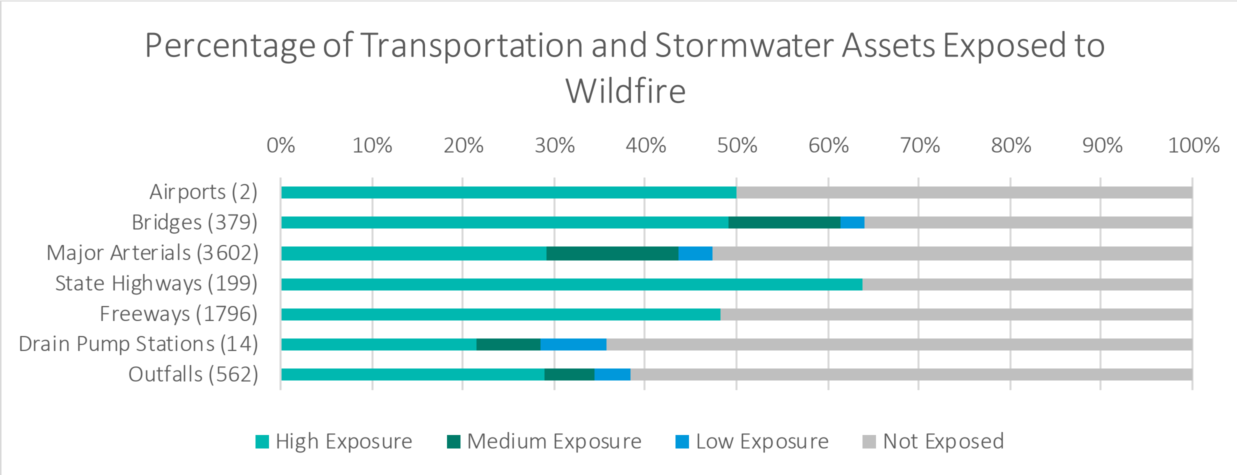

Figure 33. Transportation and storm water critical assets exposed to wildfire. The value after each asset name indicates the asset count.

Levee Exposure

The levees directly overlap with the 100-foot setback from the native vegetation hazard zone (see Figure 34), which confers a high exposure score, and the river area generally contains vegetation that is relatively dry in summer months.

Figure 34. Levee exposure to the 100-foot setback fire hazard zone. Fire hazard zone data obtained from the City of San Diego. Map created 2020.

Transportation and Storm Water Sensitivity and Adaptive Capacity to Wildfire

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of all transportation and storm water critical asset types to wildfire. The results of this analysis are presented in Table 50.

Table 50. Sensitivity and Adaptive Capacity of Transportation and Storm Water Critical Asset Types to Wildfire

Airports	
Wildfire Sensitivity Rating: High Wildfire could cause damage to airport facilities and airplanes. Additionally, smoke from wildfires could limit the ability of planes to safely take off and land, and general wildfire hazards (fire, debris, smoke) could limit access to the airports.	*Wildfire Adaptive Capacity Rating: Medium* Airports have defensible space to protect against burning. In addition, only Montgomery-Gibbs Executive Airport faces potential exposure to wildfire, so there is redundancy in Brown Field Municipal Airport (not exposed) as well as in the major commercial airports, such as San Diego International Airport (Consultation with City of San Diego READ, 2019).
Bridges	
Wildfire Sensitivity Rating: High Burned bridges should be replaced after wildfires (City of San Diego, 2007). The cost to replace bridges is relatively high (City of San Diego, 2019).	*Wildfire Adaptive Capacity Rating: High* The City has budgeted for proactive tree pruning and removes dead trees within the developed right-of-way. Other brush management is conducted based on Fire Marshall requests, which prioritize areas near habitable structures (Consultation with City of San Diego TSWD, 2019).
Major Arterials	
Wildfire Sensitivity Rating: High Wildfire could damage roads in several ways. Unsafe conditions and damage could lead to road closures. Typical asphalt mixtures could ignite or melt/excessively soften. Debris from fires and subsequent landslides could block roads (Carvel & Torero, 2006; Cannon & DeGraff, 2009; Jofré, Romero, & Rueda, 2010).	*Wildfire Adaptive Capacity Rating: High* Most major roads have sidewalks that create a small defensible space as well as development of the surrounding areas. The City has budgeted for proactive tree pruning and removes dead trees within the developed right-of-way. Other brush management is conducted based on Fire Marshall requests, which prioritize areas near habitable structures (Consultation with City of San Diego TSWD, 2019).
Drain Pump Stations	
Wildfire Sensitivity Rating: High Wildfires could burn and damage drain pump stations. Wildfires could also alter hydrology by changing vegetation, increasing runoff and resulting in	*Wildfire Adaptive Capacity Rating: Medium* The City has a brush management program in place to reduce wildfire risk around critical assets. As of 2019, the cost to replace one drain pump station could be between $4.5 and $6 million

more sediment that could block drainage and damage structures (U.S. DOT, 2018).	(Consultation with City of San Diego TSWD, 2019).
Outfalls	
Wildfire Sensitivity Rating: Medium Wildfires could alter hydrology by changing vegetation, increasing runoff and resulting in more sediment that could block drainage and damage structures (U.S. DOT, 2018). This impact would be caused by upstream factors; wildfires are unlikely to directly burn and/or damage outfalls themselves due to construction materials and placement near bodies of water.	*Wildfire Adaptive Capacity Rating: Medium* The City has a brush management program in place to reduce wildfire risk around critical assets. As of 2019, the cost to replace one storm water outfall could be between $1.35 and $2 million (Consultation with City of San Diego TSWD, 2019).
Levees	
Wildfire Sensitivity Rating: Medium Fire might have an impact on the structure of earthen levees themselves, essentially "baking" the soil and making them more hydrophobic. The larger impact, however, would be the potential for wildfires to increase peak flows during post-fire floods due to the impact of the wildfire on the watershed. According to the USDA, "hydrophobic conditions, bare soils, and litter and plant cover loss will cause flood peaks to arrive faster and at higher levels" (USDA, 2005). However, since the San Diego area is largely urbanized, this specific risk is lessened.	*Wildfire Adaptive Capacity Rating: High* The City has an existing fire management program to mitigate the possibility for vegetation around assets to catch and spread fires. The levees are in an urbanized area, which increases the availability of firefighting resources.

Open Space and Environment Vulnerability Findings

Open Space and Environment assets include those managed by the City's Parks and Recreation Department, Environmental Services Department (ESD), Public Utilities Department (PUD), and Real Estate Assets Department (READ). The following asset types are considered critical: conservation areas/open space/source water land, community parks, the Miramar landfill, the City's CNG fueling station, and beaches. Not all assets in this list were found to be exposed to climate hazards.

Conservation areas/open space/source water land assets include open space parks (those that do not serve a human/recreational purpose), Multi-Habitat Planning Area (MHPA) land owned and managed by the PUD, and vernal pools conserved under the Vernal Pool Habitat Conservation Plan (VPHCP). MHPA land and VPHCP land are both managed for the purpose of conservation and habitat protection, while land managed by the PUD serves the primary role of source water and watershed protection. Community Parks include developed parks that serve an active recreational purpose. While recreation centers are often associated with parks, these buildings were treated as a separate asset class and are included in the

"Additional Asset Vulnerability Findings" section below. The Miramar Landfill and CNG Fueling Station are managed by the ESD. Beaches are managed by the Parks and Recreation Department.

The results of the vulnerability assessment for open space and environment are shown in Table 51. "N/A" indicates that the assets were not found to be exposed to the hazard, so sensitivity and adaptive capacity were not assessed, and the asset types were deemed not vulnerable.

Of the open space and environment critical asset types considered, conservation areas/open space/source water land, community parks, and beaches may be exposed to all climate change hazards. The Miramar Landfill and CNG Fueling Station face exposure only to heat and wildfire, hazards to which all open space and environment critical asset types face exposure.

Table 51. Vulnerability of Open Space and Environment Critical Asset Types to Climate Change Hazards[43]

	Sea Level Rise (SLR)	Storm Surge with SLR	Coastal Erosion	Precipitation	Heat	Wildfire
Conservation Areas/Open Space/Source Water Land	High	High	High	High	High	High
Community Parks	High	Medium	High	Medium	Medium	High
Miramar Landfill	N/A	N/A	N/A	N/A	Low	Medium
CNG Fueling Station	N/A	N/A	N/A	N/A	Low	Low
Beaches	High	Medium	High	Medium	Low	Medium

Open Space and Environment Consequences

City parks and natural areas provide a variety of recreational opportunities, ecosystem services, and habitat value. Ecosystem services are those provided by nature that contribute to human and environmental wellbeing; they include provisioning services (e.g., providing food and water), regulating services (e.g., climate control and flood prevention), supporting services (e.g., nutrient cycling), and cultural services (e.g., recreation and heritage) (Buttke, 2014). Damage to these areas could have

[43] The vulnerability scores were calculated using a combination of spatial asset data provided by the City of San Diego or SanGIS, the best available spatial projections and localized modeling for the chosen climate hazard scenarios, and an assumption of asset type-level (general) of sensitivity and adaptive capacity based on literature reviews and high-level department consultations. The scores reported here do not reflect the vulnerability of specific, individual assets, but rather an assumption of asset type vulnerability. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

significant consequences for City services, natural resources and environment, human health, and social equity. For example, habitat loss could be detrimental to many threatened and endangered species.

Open space and environment assets also include built infrastructure, such as the Miramar landfill and CNG fueling station. Damage to these assets could have significant consequences for City services, human health, and social equity. For example, mulch and composting reserves and processing from the landfill would be depleted if there was a fire.

Illustrative examples of the consequences of open space and environmental damage, disruption, and failure are presented in Table 52. This table is provided purely to illustrate potential impacts; it is not meant to imply that these impacts will definitively occur, nor is this list fully comprehensive of all potential consequences to all asset types.

Table 52. Illustrative Consequences of Open Space and Environmental Asset Damage, Disruption, or Failure

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
Conservation Areas/Open Space/Source Water Land	City Services Human Health Historical, Tribal Cultural, and Archaeological Resources Natural Resources and Environment	Conservation areas and open space in the City of San Diego provide crucial ecosystem services such as the provisioning of clean air and water and climate regulation. If conservation areas are damaged, endangered species could be at increased risk species survival. If habitats of sensitive MHPA and VPHCP-covered species are subject to frequent disturbance or destruction, resources may be needed to adequately conserve these species. In addition, in the event of damage, more insects, pests, or invasive species could move in and out-compete native species. This land includes PUD watershed land managed primarily for the purpose of source water capture. If this land is impacted, then the City's water supply and water quality could be impacted. Conservation areas and open space can include a variety of historical, tribal cultural, and archaeological resources, including the Coronado Belt Line, Piedras Pintados, and various archaeological sites, all of which are City-owned designated historical resources, as well as sites that are covered under the Native American Heritage Commission Sacred Lands File. Additionally, other historical, tribal cultural, and archaeological resources within City-owned conservation and open space areas that are not currently designated may be eligible for designation pending evaluation. Damage to these resources could impact their ability to convey

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
		historical and cultural information and value.
Community Parks	Human Health Social Equity Historical, Tribal Cultural, and Archaeological Resources Natural Resources and Environment	Community parks serve a variety of functions in the City of San Diego. They are used for recreation, exercise, as gathering spaces, and sites of natural, historical, tribal cultural, and archaeological resources. Loss of or damage to community parks would interfere with their ability to serve these various functions.
Miramar Landfill	City Services Human Health	This landfill, which is the only City-run landfill, accepts around 3,900 tons of trash per day (City of San Diego, 2019e). If this facility is damaged, trash would need to be put elsewhere to maintain this service. Mulch and composting reserves and processing would be depleted if there was a fire. If the landfill's gas facilities are damaged, the Metropolitan Biosolids Center's energy supply may need a non-renewable backup energy supply, which could increase its greenhouse gas emissions. In the event of a natural disaster, landfills are crucial mitigation hubs: • Water trucks, bulldozers, and other on-site equipment act as key resources for fire suppression and recovery. Damage to this equipment could hinder disaster mitigation efforts. • Local enforcement agencies will allow exceptions to materials that would be typically accepted for trash collection to aid in the cleanup effort. Occupational Safety and Health Administration (OSHA) standards require monitoring workers for risk of heat-related illness and shortening work periods and increasing rest periods as temperature rises. In the case of a wildfire, and destruction of the landfill gas collection system equipment, methane emissions from the landfill could affect surrounding or downwind neighborhoods, disproportionately affecting communities until repairs to the gas collection system are made.

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
CNG Fueling Station	City Services	The CNG fueling station serves the City's fleet, which includes vehicles from a variety of departments. If the CNG fueling station is compromised by climate-related hazards, the fleet would have to look to other sources (privately-owned fueling stations) to maintain normal operations.
Beaches	City Services Human Health Social Equity Historical, Tribal Cultural, and Archaeological Resources Natural Resources and Environment	Like community parks, beaches in the City serve a variety of functions, including tourism, recreation, habitat, and as sites for historical, tribal cultural, and archaeological resources. Beaches can also help the public stay cooler during heat events, as the coastline in San Diego is generally cooler than areas further inland and provides access to the ocean. The beach also provides a buffer between the ocean and the built infrastructure of the City, helping to absorb coastal flooding. If beaches were to be impacted by climate hazards, they could lose the ability to provide these key amenities.

Open Space and Environment Vulnerability to Coastal Hazards

Coastal hazards include sea level rise, storm surge, and erosion. Daily flooding was used to estimate exposure to chronic inundation and represents the extent of flooding that would occur at high tide on average each day under each sea level rise scenario. Storm surge (100-year storm) flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm under each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

The City found that community parks, conservation areas/open space/source water land, and beaches are vulnerable to both coastal flooding and erosion. All erosion scenarios assume 2.0 meters of sea level rise (which is the upper range for 2100).

The results of the vulnerability assessment of open space and environment critical asset types to coastal hazards are shown in Table 53, Table 54, and Table 55. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to coastal hazards. Table 56 provides the rationale for the sensitivity and adaptive capacity scores.

Table 53. Vulnerability of Open Space and Environment Critical Asset Types to Sea Level Rise

SLR	Conservation Areas/ Open Space/Source Water Land	Community Parks	Miramar Landfill	CNG Fueling Station	Beaches
Exposure	High	High	Not	Not	High

			exposed	exposed	
Sensitivity	High	High	N/A	N/A	High
Adaptive Capacity	Medium	Low	N/A	N/A	Medium
Vulnerability	High	High	N/A	N/A	High

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 54. Vulnerability of Open Space and Environment Critical Asset Types to Storm Surge with Sea Level Rise (One Hundred-Year storm)

Storm Surge with SLR	Conservation Areas/ Open Space/Source Water Land	Community Parks	Miramar Landfill	CNG Fueling Station	Beaches
Exposure	High	High	Not exposed	Not exposed	High
Sensitivity	High	Medium	N/A	N/A	Medium
Adaptive Capacity	Medium	High	N/A	N/A	Medium
Vulnerability	High	Medium	N/A	N/A	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 55. Vulnerability of Open Space and Environment Critical Asset Types to Coastal Erosion at Medium-High Risk Aversion Scenario of 2m of Sea Level Rise

Coastal Erosion	Conservation Areas/ Open Space/Source Water Land	Community Parks	Miramar Landfill	CNG Fueling Station	Beaches
Exposure	High	High	Not exposed	Not exposed	High
Sensitivity	High	High	N/A	N/A	High
Adaptive Capacity	Medium	Medium	N/A	N/A	Medium
Vulnerability	High	High	N/A	N/A	High

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Open Space and Environment Exposure to Coastal Hazards

A specific subset of open space and environment critical assets may be exposed to coastal hazards (Figure 35).[44] The landfill and CNG fueling station are not exposed.

Sea Level Rise Projections for San Diego

2030: 0.25 m

2050: 0.5 to 0.75 m

2100: 1.0 to 2.0 m

Beaches face the highest proportional exposure from sea level rise: thirty-nine percent of San Diego's beach area is projected to be exposed to sea level rise by 2030, and up to seventy-one percent is projected to be exposed to sea level rise by 2100 (Figure 35). Community parks and conservation areas/open space/source water land also face high exposure to sea level rise, but a much smaller portion of the assets are projected to be exposed.

The number of assets and acres brought into flooding zones under storm surge with sea level rise does not increase significantly; however, assets are exposed earlier in time to storm surges than they are to sea level rise alone (Figure 36). Sixty percent of beach areas become flooded under storm surge conditions with 0.25 meters of sea level rise (2030). Community parks and conservation areas/open space/source water land still face very little exposure to storm surge with sea level rise flooding.

Different assets may become exposed to cliff erosion by 2100, but beaches face the greatest proportional exposure to cliff erosion (Figure 37). Fifteen percent of beach area may be exposed if no adaptive action is taken. This is beach area that currently abuts cliffs, such as along Torrey Pines or Sunset Cliffs Natural Park.

As with cliff erosion, beaches face the greatest exposure to beach erosion: up to twenty percent of beach area may be exposed (Figure 38).

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the coastal hazard scenarios.

[44] Due to project constraints, the project team was unable to analyze the exposure of the 30,321 acres of conservation areas/open space/source water land outside the City of San Diego boundary to coastal hazards. This inflates the portion of this asset type that is reported as not exposed to coastal hazards; however, much of this land is inland and would not be exposed.

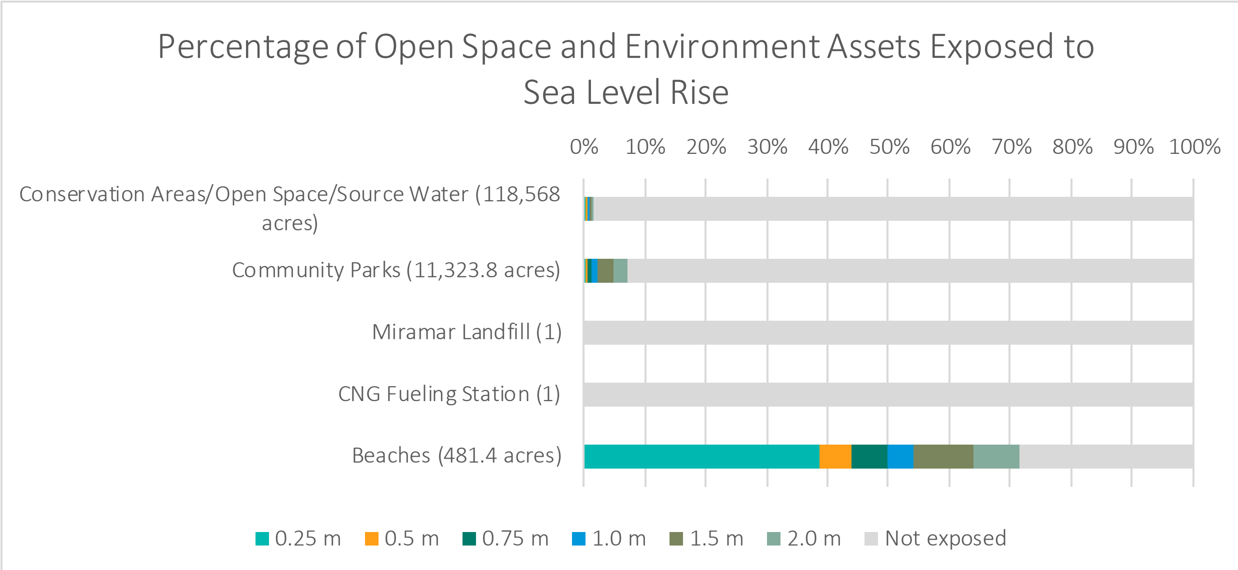

Figure 35. Open space and environment critical assets exposed to sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario.

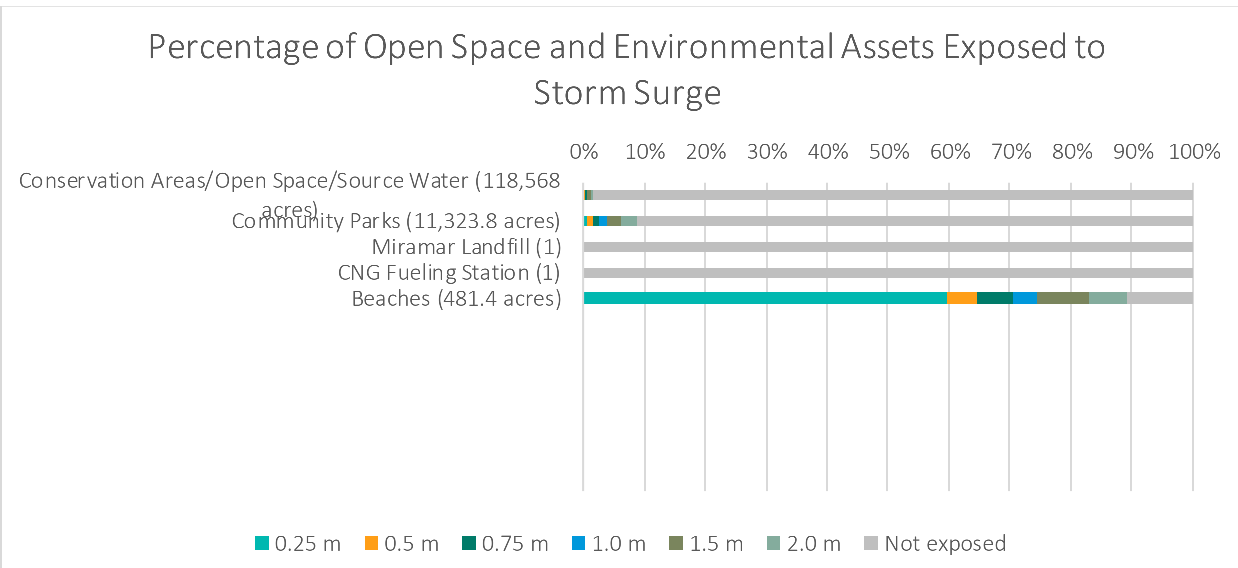

Figure 36. Open space and environment critical assets exposed to storm surge with sea level rise; this includes the 100-year storm on top of sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario. Assets would be exposed to storm surge prior to being exposed to average daily flooding, so more assets in this graph tend to be exposed under lower sea level rise amounts.

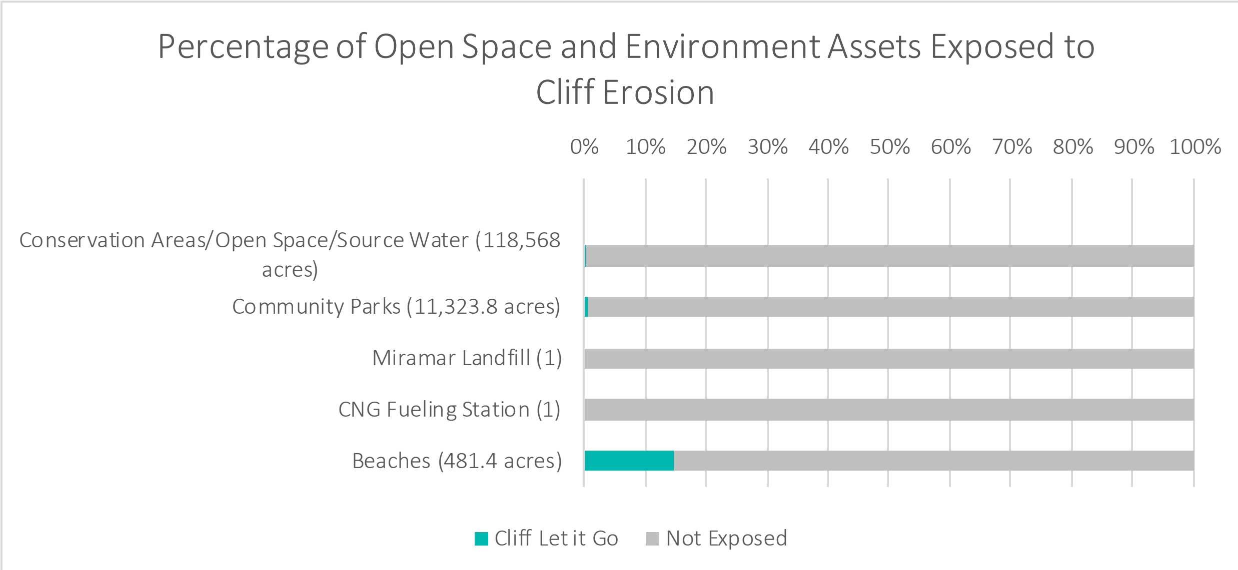

Figure 37. Open space and environment assets critical exposed to cliff erosion. The value after each asset name indicates the asset count. "Cliff let it go" represents the number of assets exposed to flooding if the City does not implement coastal armoring and allows cliff retreat and erosion.

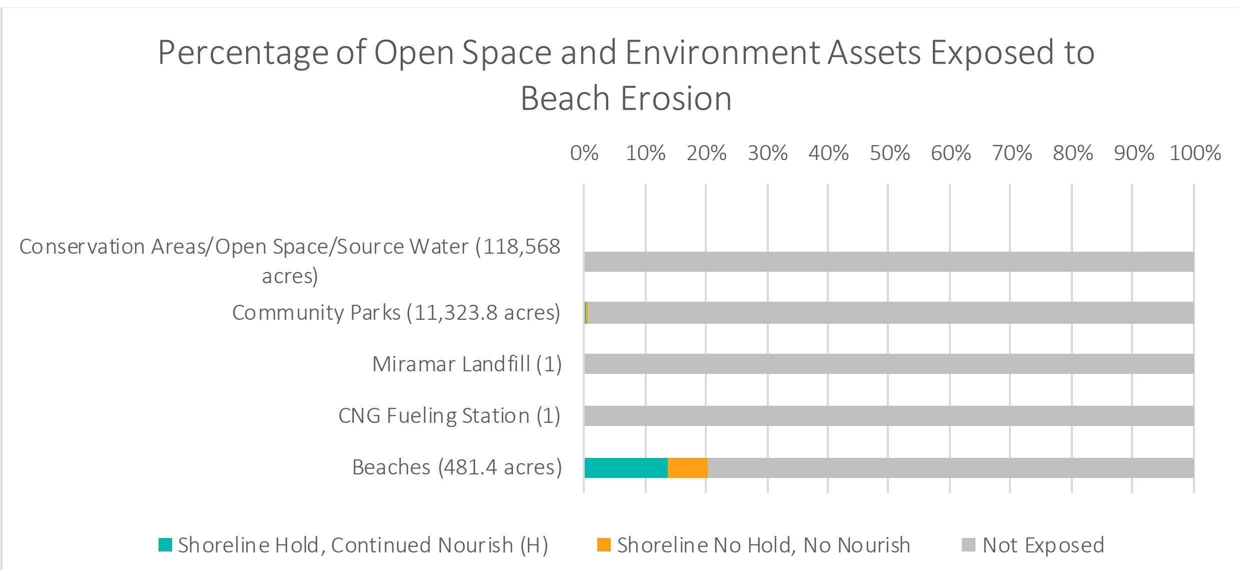

Figure 38. Open space and environment assets critical exposed to beach erosion. The value after each asset name indicates the asset count. "Shoreline Hold, Continued Nourish" represents the number of assets exposed to flooding if the City continues beach nourishment and sea wall repair, while "Shoreline No Hold, No Nourish" represents the number of assets exposed if the City were to stop beach nourishment and seawall repair.

Open Space and Environment Sensitivity and Adaptive Capacity to Coastal Hazards

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of conservation areas/open space/source water land, community parks, and beaches to coastal hazards. The results of this analysis are presented in Table 56.

Table 56. Sensitivity and Adaptive Capacity of Open Space and Environment Critical Asset Types to Coastal Hazards

Conservation Areas/Open Space/Source Water Land	
SLR Sensitivity: High Conservation areas could experience damage or significant alteration if exposed to chronic flooding. The changes to ecosystems that come with sea level rise impacts—changes in sediment, nutrient availability, and salinity—could lead to shifts in habitat locations and may cause certain habitats to shrink or disappear (ICLEI, 2017). Species (including endangered species) may become locally extirpated if certain habitats in conservation areas and parks are lost (Consultation with City of San Diego Parks and Recreation Department, 2019).	*SLR Adaptive Capacity:* Medium If there is sufficient available space and the areas do not abut human or natural barriers, some habitats may be able to migrate inland to reduce exposure to chronic flooding. However, not all habitat types or species would be able to keep pace with sea level rise. Sensitive plant species that have limited distribution and rely on specific habitats within these areas may require assisted relocation. Banking seed from sensitive plant species now (while they are still here) could help ensure the future persistence of these species and is a strategy currently in place at the San Diego Zoo (Davitt, 2018).
Storm Surge with SLR Sensitivity: High Flooding from storms may temporarily disrupt conservation areas, but water could likely be absorbed into the ground. However, the Rare Plant Working Group has identified several rare species that are a high priority for regional conservation and are threatened by more frequent storm surges. As storm surges push salinity farther upstream into traditionally freshwater areas, freshwater species further inland may be threatened and habitat areas may shift (Consultation with City of San Diego Parks and Recreation Department, 2019).	*Storm Surge with SLR Adaptive Capacity:* Medium Most natural areas are able to recover from periodic flooding. Certain species may not be able to adapt to shifting storm surge regimes and/or greater salinity being pushed farther upstream and inland; this includes some rare species identified by the Rare Plant Working Group (Consultation with City of San Diego Parks and Recreation Department, 2019).
Coastal Erosion Sensitivity: High Erosion could erase or significantly alter habitable land within conservation areas. The changes to ecosystems that come with sea level rise impacts—changes in sediment, nutrient availability, and salinity—could lead to shifts in habitat locations and may cause certain habitats to shrink or disappear (ICLEI, 2017). Coastal bluffs such as those at Point Loma and La Jolla are home to sensitive species that might be impacted if there is more coastal erosion. The	*Coastal Erosion Adaptive Capacity:* Medium Inland migration might be possible, though most of these habitats abut human or natural barriers. Sensitive plant species that have limited distribution and rely on specific habitats within these areas may require assisted relocation. Banking seed from sensitive plant species now (while they are still here) could help ensure the future persistence of these species and is a strategy currently in place at the San Diego Zoo

Torrey Pines Bluffs are another conserved sensitive area that could be affected by erosion (Consultation with City of San Diego Parks and Recreation Department, 2019).	(Davitt, 2018).
Community Parks	
SLR Sensitivity: High Chronic flooding could limit access to and use of parks and fundamentally change habitat types. Chronic flooding could also pose a threat to public safety.	*SLR Adaptive Capacity: Low* The City has a beach maintenance program in place that could be updated to account for SLR impacts.
Storm Surge with SLR Sensitivity: Medium Periodic flooding may temporarily limit access to parks, but once flood waters recede the park should be usable again with limited clean up (Consultation with City of San Diego Parks and Recreation Department, 2019).	*Storm Surge with SLR Adaptive Capacity: High* Parks could be modified to mitigate flooding (e.g., increase use of porous materials on trails, parking lots, and playgrounds; high use of natural infrastructure; flood walls).
Coastal Erosion Sensitivity: High Erosion could render the recreational functions of parks useless and pose a threat to public safety.	*Coastal Erosion Adaptive Capacity: Medium* The City of San Diego has some measures in place currently to deal with coastal erosion. For example, the Parks and Recreation Department annually stockpiles sand and kelp to build winter storm berms and to repair erosion caused by high tides and surf (Consultation with City of San Diego Parks and Recreation Department, 2019). In addition, the City recently updated its Coastal Erosion Assessment (2018), which helps pinpoint areas for erosion mitigation efforts.
Beaches	
SLR Sensitivity: High Narrowing sandy areas could limit a beach's ability to provide valuable recreational and ecological services. Current beaches may shrink as sea levels rise.	*SLR Adaptive Capacity: Medium* If allowed, beaches will move landward as sea levels rise. If constrained by coastal protection structures or by natural coastal, beaches will erode as sea levels rise (Spiegel, 2016). In San Diego, most beaches abut an area of urban development and therefore have limited space for inland migration as sea levels rise. Beach nourishment is a common and available approach to combating erosion and has been widely used in San Diego (Brennan, 2018). Beach nourishment provides an additional buffer to beach erosion in the short term.

Storm Surge with SLR Sensitivity: Medium	*Storm Surge with SLR Adaptive Capacity: Medium*
Periodic flooding has the potential to limit access to beaches and wash away sand. Once floods recede, the beach could generally resume functionality—albeit with reduced long-term functionality as sea levels rise.	The adaptive capacity of beaches to storm surge and sea level rise is enhanced by beach nourishment that provides an additional buffer to beach erosion. There are measures the City could take to mitigate flood damage to beaches from storm surge (e.g., living shorelines, beach nourishment). However, long-term sea level rise would lead to long-term changes in the shoreline over time as sea levels rise and storm surge impacts reach farther inland (Spiegel, 2016).
Coastal Erosion Sensitivity: High By definition, coastal erosion is the inland migration of the shoreline as beaches and cliffs are eroded into the ocean. Thus, beaches could be highly impacted by coastal erosion.	*Coastal Erosion Adaptive Capacity: Medium* Beach nourishment is a common and available approach to combating erosion and has been widely used in San Diego (Brennan, 2018). Nourishment provides an additional buffer to beach erosion in the short term. Common hard infrastructure protection such as sea walls and bulkheads could increase rates of erosion at the infrastructure's edge (Spiegel, 2016).

Open Space and Environment Vulnerability to Precipitation Changes

The City found that all open space and environment critical asset types except the Miramar Landfill and CNG Fueling Station are vulnerable to precipitation-driven flooding and changes in precipitation.

The results of the vulnerability assessment of open space and environment asset types to precipitation-driven flooding are shown in Table 57. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to precipitation impacts. Table 58 provides the rationale for the sensitivity and adaptive capacity scores.

Table 57. Vulnerability of Open Space and Environment Critical Asset Types to Precipitation-driven Flooding

	Conservation Areas/Open Space/Source Water Land	Community Parks	Miramar Landfill	CNG Fueling Station	Beaches
Exposure	High	High	Not exposed	Not exposed	High
Sensitivity	High	Medium	N/A	N/A	Medium
Adaptive Capacity	Medium	High	N/A	N/A	High
Vulnerability	**High**	**Medium**	**N/A**	**N/A**	**Medium**

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Open Space and Environment Exposure to Precipitation-driven Flooding

Only two open space and environmental critical asset types are *not* exposed to precipitation impacts: the landfill and CNG fueling station (Figure 39).

Eight percent of community parks, eleven percent of conservation areas/open space/source water land area, and thirty-two percent of beach area lie in floodplains. Most of these open space and environment assets already face exposure under the 100-year floodplain; with a smaller proportion potentially becoming exposed under the 500-year flood scenario.[45]

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to precipitation-driven flooding.

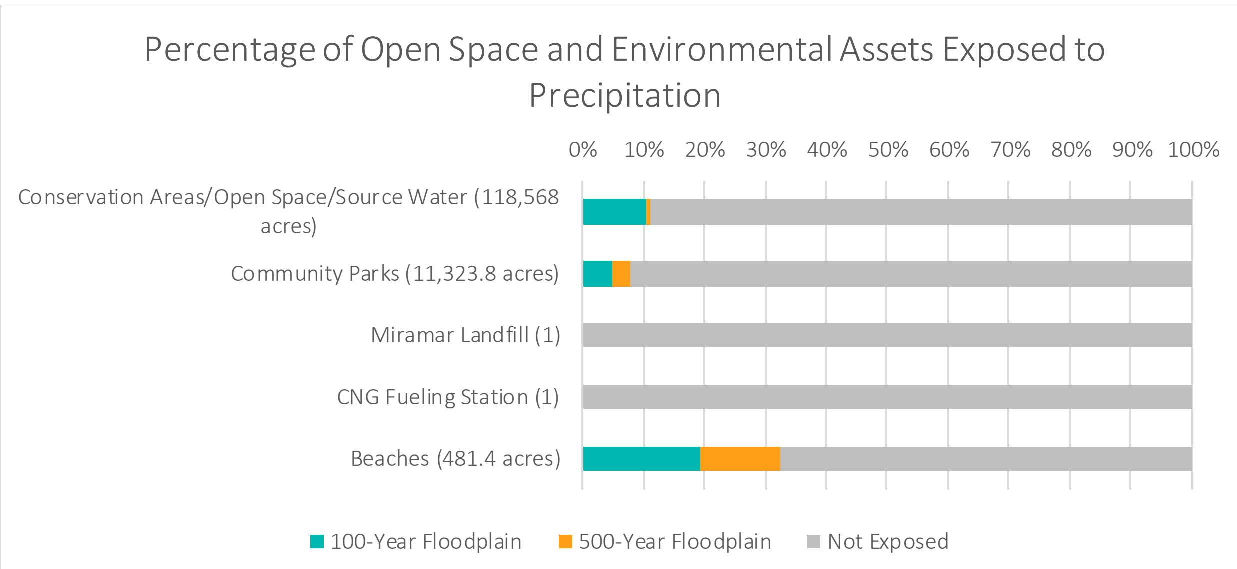

Figure 39. Open space and environment critical assets exposed to precipitation. The value after each asset name indicates the asset count. All assets in the 100-year floodplain also lie in the 500-year floodplain; the orange colored bar for the 500-year floodplain shows assets that are outside the 100-year floodplain but experience flooding under more extreme precipitation events.

[45] Due to project constraints, the project team was unable to analyze the exposure of the 30,321 acres of conservation areas/open space/source water land outside the City of San Diego boundary to coastal hazards. This inflates the portion of this asset type that is reported as not exposed to precipitation-driven flooding.

Open Space and Environment Sensitivity and Adaptive Capacity to Precipitation-driven Flooding

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of conservation areas/open space/source water land, community parks, and beaches to precipitation. The results of this assessment are shown in Table 58.

Table 58. Sensitivity and Adaptive Capacity of Open Space and Environment Critical Asset Types to Precipitation-driven Flooding

Conservation Areas/Open Space/Source Water Land	
Precipitation Sensitivity Rating: High	*Precipitation Adaptive Capacity Rating: Medium*
Flash flooding has the potential to impact habitats. Increased precipitation patterns could encourage the growth of invasive species, which increases the risk of habitat type conversion (especially for sensitive, rare native habitat types such as coastal scrub and maritime chaparral communities) to exotic grasslands. In addition, flooding in watersheds could impact water quality by bringing more nutrients and total dissolved solids into the water supply. This could also increase eutrophication (Consultation with City of San Diego Parks and Recreation Department, 2019). Studies show that sensitive native habitats are facing difficulty when faced with long-term drought in Southern California and may not be able to adapt to climate-induced changes in drought regimes (Consultation with City of San Diego Parks and Recreation Department, 2019).	If precipitation encourages the growth of invasive species, land management to prevent type conversion would become more intensive and require funding. If the region is experiencing drought, resilience measures such as controlling and managing invasive pests, planting tolerant and diverse plant species assemblages, and assisting migration could be undertaken to restore habitats. Notably, these measures require significant budgets and may be limited by available funding.
Community Parks	
Precipitation Sensitivity Rating: Medium	*Precipitation Adaptive Capacity Rating: High*
Storm events could cause erosion on trails. Past events have blown down trees, which could be costly to remove (FEMA disaster 1731 and February 2017 IDE). Trails could close for two or more days after rain events due to flooding, erosion, and unsafe conditions (City of San Diego Parks and Recreation Department, 2011). Periodic flooding may temporarily limit access to parks, but once flood waters recede the park should be usable again with limited clean up (Consultation with City of San Diego Parks and	Parks could be modified to mitigate flooding (e.g., increase use of porous materials on trails, parking lots, and playgrounds; high use of natural infrastructure.) However, it might be difficult to fully protect trails without limiting the public’s access to some features of parks.

Recreation Department, 2019).	
Beaches	
Precipitation Sensitivity: Medium Beaches are not very sensitive to rain-driven flooding. However, runoff from urbanized inland areas could cause localized beach erosion around drainage outfalls and has the potential to carry pollutants to the beach and coastal waters. (EPA, 2016).	*Precipitation Adaptive Capacity: High* Beaches naturally absorb periodic rainwater flooding and will allow the water to filter or run off into the ocean. There is localized reduction in adaptive capacity when drainage outfalls discharge onto beaches, as this increases the volume of storm water the beaches experience. Runoff pollution from further inland could be mitigated through increased groundwater infiltration (e.g., increased green spaces).

Open Space and Environment Vulnerability to Heat

The City found that all open space and environment critical asset types face exposure to heat. However, beaches and CNG fueling stations' low exposures indicates nearly negligible vulnerability for these types of asset, as areas with low urban heat island scores are expected to experience extreme heat events less frequently than areas with higher scores.

While the precipitation section above focused on vulnerability to increases in precipitation and precipitation-based flooding events, vulnerability to heat discussed in this section could be accentuated by a heightened risk of drought, which could particularly affect open space and environmental assets.

The results of the vulnerability assessment of open space and environment critical asset types to heat are shown in Table 59. Cells that are shaded in green indicate asset types that should be prioritized for further attention toward the development of adaptation strategies based on their vulnerability scores. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to heat. Table 60 provides the rationale for the sensitivity and adaptive capacity scores.

Table 59. Vulnerability of Open Space and Environment Critical Asset Types to Heat

	Conservation Areas/ Open Space/Source Water Land	Community Parks	Miramar Landfill	CNG Fueling Station	Beaches
Exposure	High	High	Medium	Low	Low
Sensitivity	High	Low	Low	Low	Low
Adaptive Capacity	Medium	High	Medium	High	High
Vulnerability	High	Medium	Low	Low	Low

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Open Space and Environment Exposure to Heat

In San Diego, coastal areas are relatively cooler than inland areas due to the moderating impacts of the ocean and offshore winds. This coastal effect dominates the urban heat island effect in the City.

The heat island scenarios are represented as zones with scores of 0 to 100+, with higher scores denoting hotter areas (CalEPA, 2019).[46] A score of zero indicates that there is no difference in temperature over time between an urban Census tract and nearby upwind rural reference points. A score of 100 indicates that there is a difference of 7.5 degrees Fahrenheit (approx. 4.2 degrees Celsius) between these tracts over 24 hours.

Most open space and environment critical assets face exposure to heat mainly at the lower levels (0 to 20, 20 to 40, and 40 to 60 heat index range) (Figure 40).[47] For example, the Miramar landfill faces exposure at the 40 to 60 index range, while the CNG fueling station faces exposure at the 20 to 40 range. Beaches have all of their potentially exposed acres exposed at the 0 to 20 heat level range.

[46] The urban heat island index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period. To estimate the total number of degrees Fahrenheit per day, divide the Index by 24 hours and multiply by 1.8 degrees. Higher scores denote hotter areas.

[47] The project team was able to assess the exposure of all 118,568 acres of conservation areas/open space/source water land to heat, including the 30,321 acres outside of the City boundary.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the heat levels.

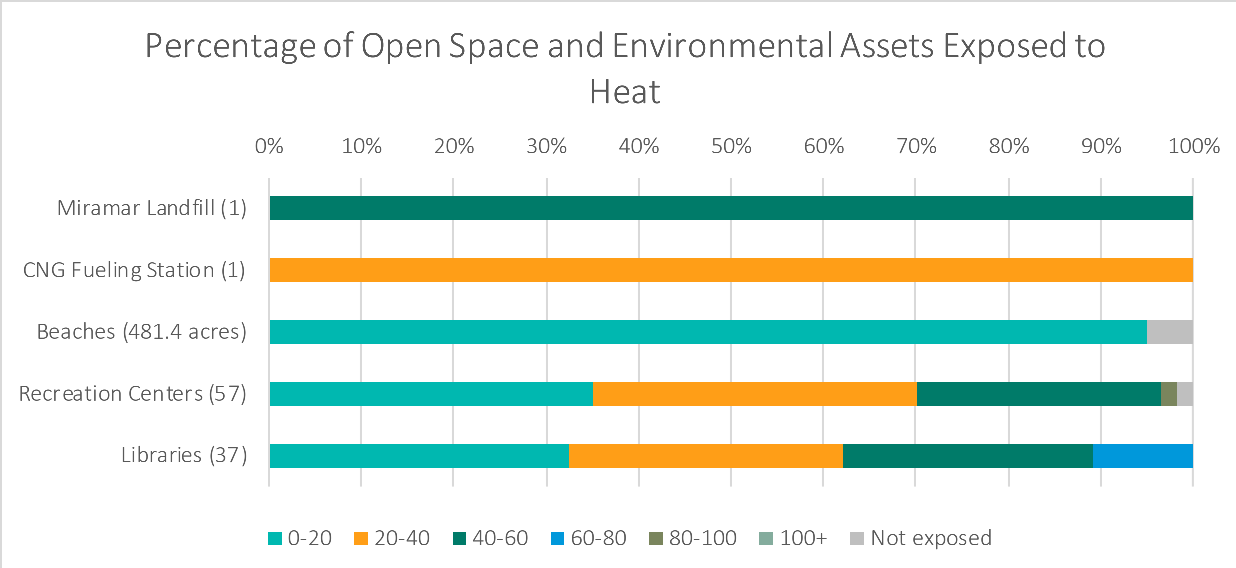

Figure 40. Open space and environment critical assets exposed to extreme heat. The value after each asset name indicates the asset count. The colored bars represent exposure to different ranges in the UHI index, with higher UHI values denoting hotter areas and therefore increased exposure to heat.

Open Space and Environment Sensitivity and Adaptive Capacity to Heat

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of all critical open space and environment asset types to heat. The results of this analysis are presented in Table 60.

Table 60. Sensitivity and Adaptive Capacity of Open Space and Environment Critical Asset Types to Heat

Conservation Areas/Open Space/Source Water Land	
Heat Sensitivity Rating: High Increased heat may lead to species shifting their ranges northward and to higher elevations. This could result in new species interactions or desynchronization of current interactions. Increased heat could also negatively affect reproductive and survival rates of sensitive species (Jennings M. K., 2018). In watersheds, higher heat could increase rates of evaporation, such that more precipitation is needed to saturate dry creek beds before flows occur that could convey water to distribution reservoirs (Consultation with City of San Diego PUD, 2019).	*Heat Adaptive Capacity Rating: Medium* If the region is experiencing intense heat, resilience measures such as controlling and managing invasive pests, planting tolerant and diverse plant species assemblages, and assisting migration could be undertaken to restore habitats. These measures require significant budgets and may be limited by available funding.
Community Parks	
Heat Sensitivity Rating: Low	*Heat Adaptive Capacity Rating: High*

Playgrounds are typically made of steel and plastic components. Plastic components have a low sensitivity to heat, though steel is somewhat more susceptible to heating up. Green space in parks is naturally cooler than built/urban landscapes. However, ongoing heat/drought events could be harmful to wildlife and greenery in parks.	Shade is an important concept in San Diego's playground design and has been incorporated where possible. Most parks have drinking fountains. The Parks and Recreation Department may experience an increased need to water the green space in community parks, which would increase routine maintenance costs.
Miramar Landfill	
Heat Sensitivity Rating: Low High temperatures exacerbate the risk of fire in some landfill facility components, including combustible mulch and compost. Collection trucks could be diverted to other facilities in case of a fire (Consultation with City of San Diego ESD, 2020). High temperatures have the potential to create stress for landfill staff, particularly those who work outdoors.	*Heat Adaptive Capacity Rating: Medium* Indoor air-conditioned areas and outdoor shaded areas may help landfill staff cool down and avoid adverse heat-induced health impacts. The City's landfill operation and gas collection processes are designed to prevent heat-driven fires at landfills. The city has monitoring systems that track leachate and methane gas production.
CNG Fueling Station	
Heat Sensitivity Rating: Low Most trucks fuel overnight so there would be limited to no operational issues.	*Heat Adaptive Capacity Rating: High* There is not a need for high heat day protocols, since most trucks fuel overnight.
Beaches	
Heat Sensitivity Rating: Low Given their proximity to the coastal zone, beaches are cooler areas within the City and are more likely to serve as refuges from extreme heat than suffer its impacts.	*Heat Adaptive Capacity Rating: High* There is not a need for beaches to adapt to extreme heat, as these areas are not projected to experience the same levels of high heat as inland areas.

Open Space and Environment Vulnerability to Wildfire

The City found that all open space and environment critical asset types are exposed to wildfire.

The results of the vulnerability assessment of open space and environment critical asset types to wildfire are shown in Table 61. The sections below provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to wildfire. Table 62 provides the rationale for the sensitivity and adaptive capacity scores.

Table 61. Vulnerability of Open Space and Environment Critical Asset Types to Wildfire

	Conservation Areas/ Open Space/Source Water Land	Community Parks	Miramar Landfill	CNG Fueling Station	Beaches

	Conservation Areas/ Open Space/Source Water Land	Community Parks	Miramar Landfill	CNG Fueling Station	Beaches
Exposure	High	High	High	Low	High
Sensitivity	High	High	Low	Medium	Low
Adaptive Capacity	Low	Medium	High	High	High
Vulnerability	High	High	Medium	Low	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Open Space and Environment Exposure to Wildfire

All open space and environment critical asset types may be exposed to wildfire, as shown in Figure 41. Over sixty percent of conservation areas/open space/source water land and community parks face exposure to wildfire.[48] The Miramar landfill is also within the high fire hazard zone. The CNG fueling station faces low exposure to wildfire. About a third of beach acreage faces exposure to wildfire, with most of this facing high exposure.

Wildfire Hazard Zones for San Diego

High: Native vegetation and 100-foot setback zones

Medium: 300-foot setback zone

Low: Fire hazard zone outside native vegetation zone and setbacks

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the fire hazard zones.

[48] Due to project constraints, the project team was unable to analyze the exposure of the 30,321 acres of conservation areas/open space/source water land outside the City of San Diego boundary to coastal hazards. This inflates the portion of this asset type that is reported as not exposed to wildfire.

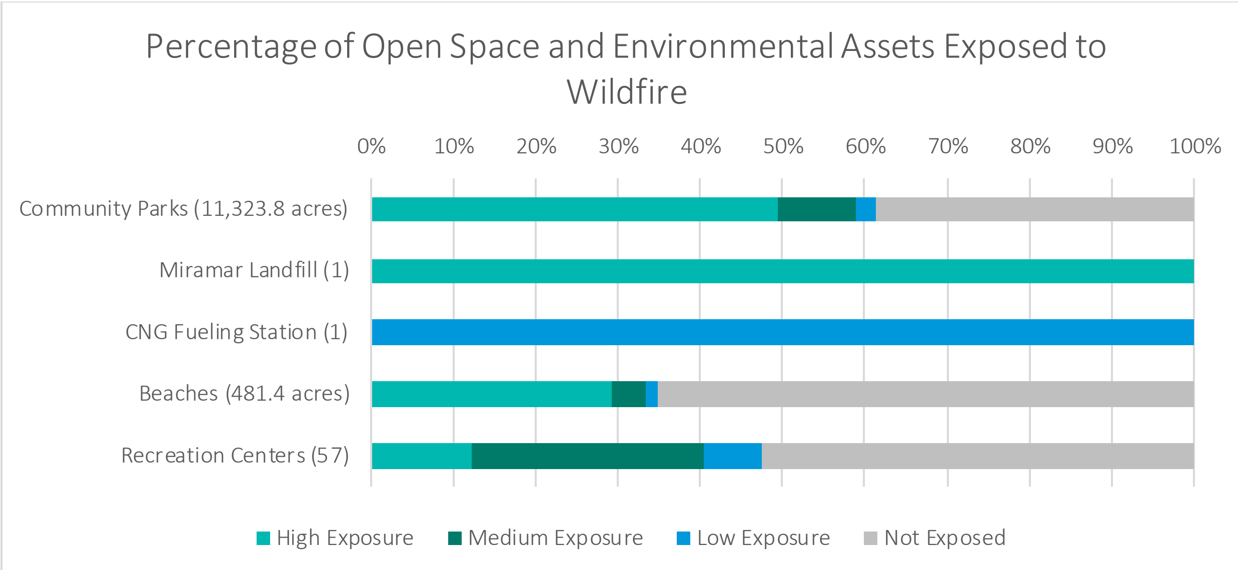

Figure 41. Open space and environment critical assets exposed to wildfire. The value after each asset name indicates the asset count.

Open Space and Environment Sensitivity and Adaptive Capacity to Wildfire

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of all open space and environment critical asset types to wildfire. The results of this analysis are presented in Table 62.

Table 62. Sensitivity and Adaptive Capacity of Open Space and Environment Critical Asset Types to Wildfire

Conservation Areas/Open Space/Source Water Land	
Wildfire Sensitivity Rating: High	*Wildfire Adaptive Capacity Rating: Low*
Wildfires could destroy critical habitats. This may lead to local extirpation of species, including endangered species. For example, California gnatcatchers are not fully recolonizing burned areas (Consultation with City of San Diego MSCP, 2019). Additionally, changing wildfire regimes may change the type of habitats present in the area from shrubland ecosystems to non-native annual grasslands (Jennings M. K., 2018). These native habitats are often home to critical and endangered species. Fires in watersheds could increase erosion and lead to toxic burned materials as well as higher volumes of pollutants and nutrients entering the water supply (Consultation with City of San Diego	Small reserves represent crucial habitat for many species, including endangered species, and there are typically no backup areas (Consultation with City of San Diego Parks and Recreation Department, 2019). Smaller reserves are often near development and are less likely to catch fire or are closer to resources for fire extinguishment. Larger conservation areas that are farther from development are more likely to burn longer, as the response time for fire extinguishment resources is greater (Consultation with City of San Diego Parks and Recreation Department, 2020). Some habitats within these reserves, such as coastal sage scrub, are resilient to fire when it occurs in infrequent intervals (roughly every twenty to thirty years). However, increased fire frequency may impede habitat recovery, resulting in a positive feedback loop and necessitating

PUD, 2019).	human intervention in the form of restoration and/or fire prevention (Consultation with City of San Diego Parks and Recreation Department, 2020). PUD is currently in the process of implementing erosion control and habitat restoration projects post-fire, which will help protect source water quality (Consultation with City of San Diego PUD, 2019).
Community Parks	
Wildfire Sensitivity Rating: High The damage to parks from wildfires depends on a park's location and arrangement of amenities within the park. If a playground were to be destroyed, it could take up to three years to replace (Consultation with City of San Diego Parks and Recreation Department, 2019).	*Wildfire Adaptive Capacity Rating: Medium* City departments have brush management plans in place to reduce risk of wildfire spreading; however, parks that are largely open space may accept some level of burning risk.
Miramar Landfill	
Wildfire Sensitivity Rating: Low Wildfires surrounding the landfill have the potential to disrupt access to the landfill and temporarily impact the City's ability to dispose of refuse. Wildfires that reach the landfill may burn above-ground structures such as gas lines but would not impact the landfill's ability to function (Consultation with City of San Diego Environmental Services Department (ESD), 2019).	*Wildfire Adaptive Capacity Rating: High* Surrounding closed sections of the landfill, highways, and Marine Corps Air Station runway areas may serve as fire breaks to the east and south. Surrounding vegetation is maintained pursuant to the brush management requirements of the Land Development Code and specifications of the General Development Plan for the landfill (Consultation with City of San Diego ESD, 2019). The landfill has an emergency plan in case of wildfire and fire suppression assets such as water tanks on-site. Trash can be diverted to other landfills or transfer stations in the case of a wildfire (Consultation with City of San Diego ESD, 2020). As the Environmental Service Department is a part of the Emergency Operations Center, interagency coordination and communication improves with each disaster event.
CNG Fueling Station	
Wildfire Sensitivity Rating: Medium If the fueling station was exposed, it would	*Wildfire Adaptive Capacity Rating: High* The fueling station has defensible space and

require repair before being available for use. The fueling station is not expected to be damaged beyond repair or further use.	SDG&E has a fueling station nearby, if needed (Consultation with City of San Diego ESD, 2019).
Beaches	
Wildfire Sensitivity Rating: Low Beaches themselves would not burn during a wildfire. The vegetation on beaches might burn. Additionally, wildfire could degrade water quality by damaging sewage infrastructure and increasing the amount of runoff into the ocean (Fry, 2019).	*Wildfire Adaptive Capacity Rating: High* There is little risk of fire spreading into the beach and therefore little need for adaptation.

Additional Asset Vulnerability Findings

Additional assets include those managed by the Real Estate Assets (READ), Parks and Recreation, Library, Fleet Services, and Public Utilities departments, along with the Commission for Arts and Culture and the Parking Organization. The following asset types are considered critical: recreation centers, libraries, City buildings, and historical, tribal cultural, and archaeological resources. While recreation centers are often associated with community parks, the two asset types were treated separately in this analysis. Community parks are included in the "Open Space and Environment Vulnerability Findings" section above. Not all assets in this list were found to be exposed to climate hazards.

The results of the vulnerability assessment for additional asset types are shown in Table 63. "N/A" indicates that the assets were not found to be exposed to the hazard, so sensitivity and adaptive capacity were not assessed, and the asset types were deemed not vulnerable.

The City found that historical, tribal cultural, and archaeological resources are highly vulnerable to all hazards except heat. This is due to their high sensitivity and low adaptive capacity: these assets could suffer severe damage from hazards, are irreplaceable when destroyed, and their historic and cultural nature requires more thought, consideration, and oversight when implementing protective measures. Note that historical resources could be restored and preserved when damage is not irreparable: in the past, repairs-in-kind have been performed on resources damaged by climate hazards. However, in general these assets carry the potential for high sensitivity and low adaptive capacity, which warranted the higher vulnerability scores. As such, these scores are a conservative estimate. Vulnerability and resilience to climate hazards vary across individual assets, particularly given the variety of forms represented by historical, tribal cultural, and archaeological resources.

The exposure assessment is based on the 2018 spatial data on assets listed under the City's Historical Resources Register; 2018 was the most recent vintage of data available at the time of analysis.[49] The number of resources on this register is dynamic and subject to change periodically. As of the end of calendar year 2019, there were 1,324 individually significant resources listed on the City's Register of Designated Historical Resources (Historic Register), including seventeen archaeological and/or tribal cultural resources. In addition, the Historic Register includes twenty-five designated historical districts that contain approximately 2,000 contributing resources, for a total of more than 3,300 historical buildings, structures, objects, districts, landscapes, tribal cultural resources, and archaeological resources listed on the Historic Register alone, with more added every month. This does not include resources listed on or determined eligible for listing on the State or National Registers that are not listed on the City's Historic Register. While the vast majority of these resources are privately owned, the City of San Diego owns more than 100 of these resources.

Table 63. Vulnerability of Additional Critical Asset Types to Climate Change Hazards[50]

	SLR	Storm Surge with SLR	Coastal Erosion	Precipitation	Heat	Wildfire
Recreation centers	High	Low	N/A	Medium	Medium	Medium
Libraries	N/A	N/A	N/A	N/A	Low	Medium
City buildings	N/A	N/A	N/A	N/A	Low	Medium
Historical, Tribal Cultural, and Archaeological Resources	High	High	High	High	Medium	High

Additional Asset Consequences

City critical asset types not included in the other sectors analyzed in this assessment (collectively referred to as "additional assets") are vulnerable to climate-related hazards. Damages to these assets could have consequences, particularly to City services or directly to historical and cultural resources.

Illustrative examples of the consequences of other City asset damage, disruption, and failure are presented in Table 64. This table is provided purely to illustrate potential impacts; it is not meant to imply that these impacts will definitively occur, nor is this list fully comprehensive of all potential consequences to all asset types.

[49] The use of these data was based on information available from the City of San Diego's GIS department. It does not represent a comprehensive analysis of all historical, tribal cultural, and archaeological assets within in the city, as it includes mostly built environment points included on the Register. A closer consideration of other assets including archaeological and tribal sites could be an area of future analysis.

[50] Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 64. Illustrative Consequences of Additional Asset Damage, Disruption, or Failure

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
Recreation Centers	City Services Human Health Social Equity Historical, Tribal Cultural, and Archaeological Resources	Recreation centers serve as community centers, which are important for after-school programs, community activities, and exercise. Use of these facilities could promote a sense of neighborhood social cohesion and could improve mental health (Perez, et al., 2015). Human health and social equity could be compromised if these centers are damaged. These centers also serve as critical facilities during emergencies, such as serving as cooling centers during heat waves (San Diego Gas and Electric (SDG&E), 2018). Damages could compromise their performance as an emergency facility, which could result in additional risks to human health. Elderly and low-income residents could experience disproportionate impacts due to damages to these facilities. The La Jolla Adult Recreation Center Club and the La Jolla Recreation Center are City-owned designated historical resources. Additionally, other recreation centers that are not currently designated may be eligible for designation pending evaluation. Damage to these buildings and associated facilities could impact their ability to convey historical and cultural information and value.
Libraries	City Services Human Health Social Equity Historical, Tribal Cultural, and Archaeological Resources	Libraries play an important role in community cohesion, acting as a meeting and social gathering space. They provide services to citizens and serve as learning centers, and employment resources. In addition, public libraries serve diverse communities by providing a place for children to go after school or resources for immigrants (e.g., English courses, citizen classes, immigration legal clinics) (City of San Diego, 2019a). Social equity could be compromised if libraries are damaged. Libraries are also used as cooling centers during extreme heat events (San Diego Gas and Electric (SDG&E), 2018; County of San Diego HHSA, 2019). Human health may be affected if these locations are not available to provide refuge. The La Jolla Public Library, the San Ysidro Free Public Library, the Ocean Beach Library, and the San Diego City Library are City-owned designated historical resources. Additionally, other libraries that are not currently designated may be eligible for designation pending evaluation. Damage to these buildings could impact their ability to convey historical and cultural information and value. Additionally, since libraries protect books and historical archives

Critical Asset	Relevant Consequence Categories	Illustrative Consequences
		and some libraries are themselves historic resources, damage to libraries could result in losses of historical and cultural resources.
City Buildings	City Services Historical, Tribal Cultural, and Archaeological Resources	City buildings include facilities where City staff work as well as where the public can interface with the City government. Impacts to these buildings could cause disruptions in the ability of City staff to carry out their day-to-day duties. There are portions of the Civic Administration site such as the plaza and surrounding buildings that have been evaluated for historic registration designation and found to be potentially eligible, though no designations have yet been made. Damage to these structures could impact their ability to convey historical and cultural information and value.
Historical, Tribal Cultural, and Archaeological Resources	Historical, Tribal Cultural, and Archaeological Resources	San Diego is home to a variety of historical, tribal cultural, and archaeological resources, including buildings, structures, objects, districts, archaeological sites and artifacts, traditional cultural properties and tribal cultural resources, historic documents, and historical or cultural landscapes (City of San Diego, 2019d). Loss or damage of these resources could result in permanent loss of historical and cultural resources that may be integral to the identity of San Diego.

Additional Asset Vulnerability to Coastal Hazards

Coastal hazards include sea level rise, storm surge, and erosion. Daily flooding was used to estimate exposure to chronic inundation and represents the extent of flooding that would occur at high tide on average each day assuming various sea level rise scenarios. Storm surge flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm assuming each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

The City found that recreation centers and historical, tribal cultural, and archaeological resources may be exposed to coastal hazards. Historical, tribal cultural, and archaeological resources are highly vulnerable to both coastal flooding and erosion, given their exposure to these hazards starting at just 0.25 m of sea level rise (projected to occur by 2030) and their high sensitivity to impacts. Sea level rise and storm events could damage or destroy built assets, permanently inundate coastal assets, and increase erosion of assets. Because these assets are critical for their historical and cultural value, they are not easily replaced (and in some cases irreplaceable) and repairs could be difficult and/or costly. Recreation centers face high vulnerability to chronic inundation with sea level rise, low vulnerability to periodic inundation with storm surge, and are not exposed to coastal erosion. All erosion scenarios assume 2.0 meters of sea level rise (which is the upper range for 2100).

The results of the vulnerability assessment of additional critical asset types to coastal hazards are shown in Table 65, Table 66, and Table 67.

The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to coastal hazards. In particular, Table 68 provides the rationale for the sensitivity and adaptive capacity scores.

Table 65. Vulnerability of Additional Critical Asset Types to Sea Level Rise

SLR	Rec Centers	Libraries	City Buildings	Historical, Tribal Cultural, and Archaeological Resources
Exposure	Low	Not exposed	Not exposed	High
Sensitivity	High	N/A	N/A	High
Adaptive Capacity	Low	N/A	N/A	Low
Vulnerability	**High**	**N/A**	**N/A**	**High**

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 66. Vulnerability of Additional Critical Asset Types to Storm Surge with Sea Level Rise (One Hundred-Year storm)

Storm Surge with SLR	Rec Centers	Libraries	City Buildings	Historical, Tribal Cultural, and Archaeological Resources
Exposure	Low	Not exposed	Not exposed	High
Sensitivity	Medium	N/A	N/A	High
Adaptive Capacity	Medium	N/A	N/A	Medium
Vulnerability	**Low**	**N/A**	**N/A**	**High**

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Table 67. Vulnerability of Additional Critical Asset Types to Coastal Erosion at Medium-High Risk Aversion Scenario of 2m of Sea Level Rise

Coastal Erosion	Rec Centers	Libraries	City Buildings	Historical, Tribal Cultural, and Archaeological Resources
Exposure	Not Exposed	Not exposed	Not exposed	Medium
Sensitivity	N/A	N/A	N/A	High
Adaptive Capacity	N/A	N/A	N/A	Low
Vulnerability	**N/A**	**N/A**	**N/A**	**High**

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Additional Asset Exposure to Coastal Hazards

> **Sea Level Rise Projections for San Diego**
>
> 2030: 0.25 m
>
> 2050: 0.5 to 0.75 m
>
> 2100: 1.0 to 2.0 m

Of the additional critical asset types, only recreation centers and historical, tribal cultural, and archaeological resources may be exposed to sea level rise and storm surge with sea level rise, as shown in Figure 42 and Figure 43. Seven historical, tribal cultural, and archaeological resources may become exposed to sea level rise starting at 0.25 meters of sea level rise (approximately 2030), and seventeen total historical, tribal cultural, and archaeological resources may become exposed under 2 meters of sea level rise, which is the high-end estimate for 2100. Only one recreation center (out of fifty-seven total) faces exposure from sea level rise, beginning with 1.5 meters of sea level rise (approximately 2100).

Storm surge with sea level rise brings eleven historical, tribal cultural, and archaeological resources into flooding zones at 0.25 meters of sea level rise (2030) and an upper end of twenty-five resources into flooding zones in 2100 (Figure 43). Eight of these twenty-five resources only face exposure to storm surge with sea level rise at the highest scenario (2 meters) of sea level rise.

Recreation centers, libraries, and City buildings are not exposed to shoreline erosion. There are six historical and cultural resources that face exposure to cliff erosion and seven that face exposure to beach erosion (assuming no beach nourishment or seawall improvements) (Figure 45).

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the coastal hazard scenarios.

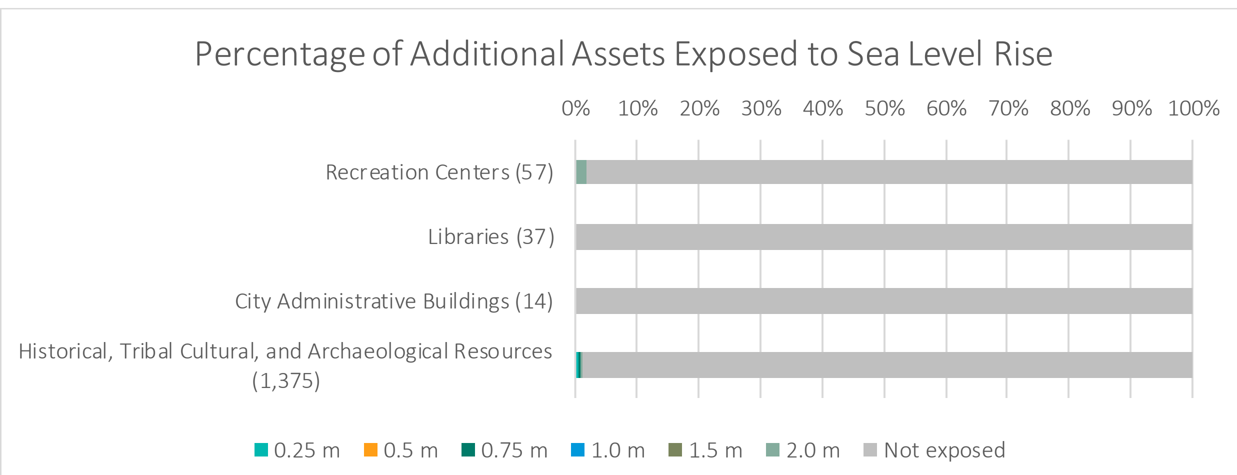

Figure 42. Additional critical assets exposed to sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario.

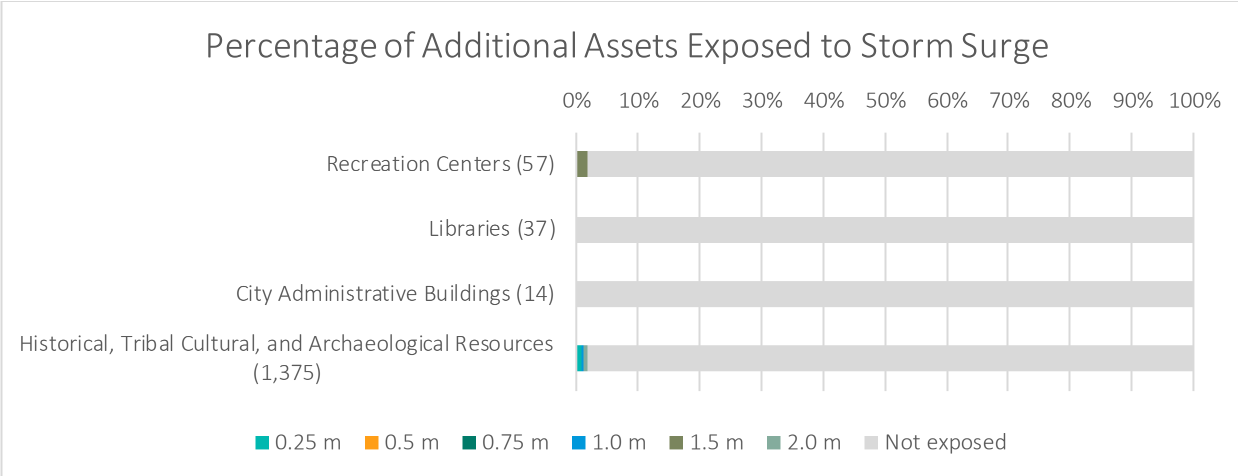

Figure 43. Additional critical assets exposed to storm surge with sea level rise; this includes the 100-year storm on top of sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario. Assets would be exposed to storm surge prior to being exposed to average daily flooding, so more assets in this graph tend to be exposed under lower sea level rise amounts.

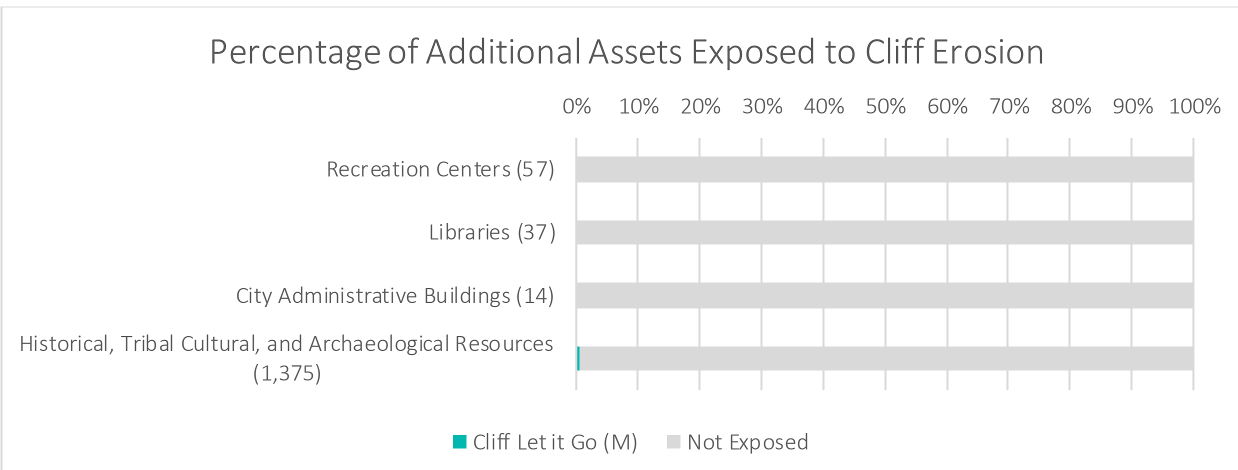

Figure 44. Additional critical assets exposed to cliff erosion. The value after each asset name indicates the asset count. "Cliff let it go" represents the number of assets exposed to flooding if the City does not implement coastal armoring and allows cliff retreat and erosion.

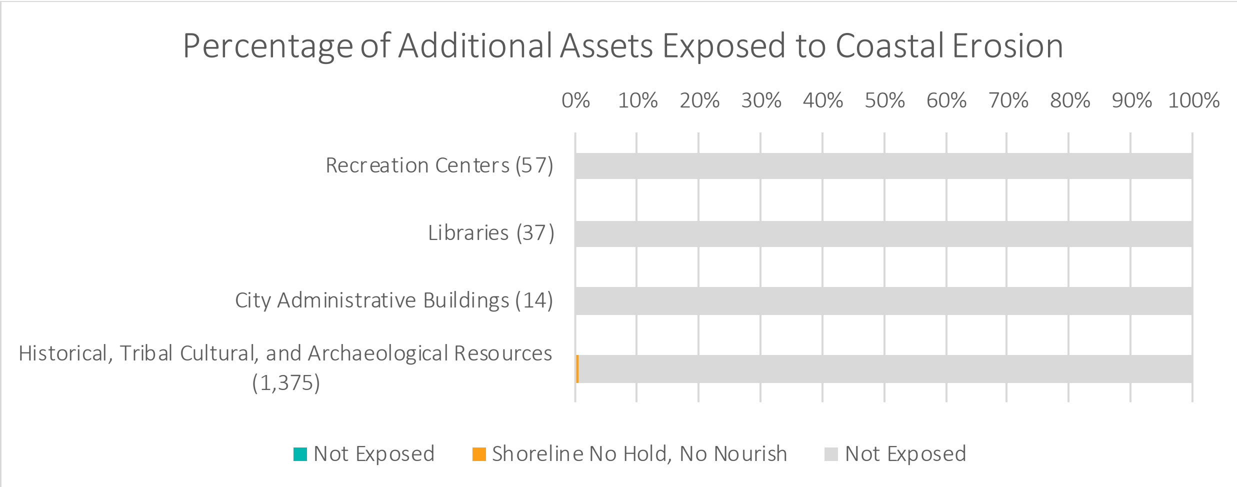

Figure 45. Additional critical assets exposed to coastal erosion. The value after each asset name indicates the asset count. "Shoreline Hold, Continued Nourish" represents the number of assets exposed to flooding if the City continues beach nourishment and sea wall repair, while "Shoreline No Hold, No Nourish" represents the number of assets exposed if the City were to stop beach nourishment and seawall repair.

Additional Asset Sensitivity and Adaptive Capacity to Coastal Hazards

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of recreation centers and historical, tribal cultural, and archaeological resources to coastal hazards. The results of this analysis are presented in Table 68.

Table 68. Sensitivity and Adaptive Capacity of Additional Asset Types to Coastal Hazards

Recreation Centers	
SLR Sensitivity: High Sea level rise could permanently inundate buildings within the projected sea level rise zone, could increase the erosion of structures, and could damage or destroy buildings and equipment (USAID 2014).	*SLR Adaptive Capacity: Low* Longer-term adaptation may be necessary if chronic flooding within the coastal zone becomes a highly likely scenario. In some areas, this may occur as soon as 2030 (with 0 to 0.25 m of sea level rise); other areas may start to experience chronic flooding around 2050 (0.5 to 0.75 m sea level rise) or 2100 (1 to 2 m sea level rise).
Storm Surge with SLR Sensitivity: Medium Recreation centers might have to be temporarily closed in the event of a flood, and flood damages would have to be repaired before the facilities could be fully functional again.	*Storm Surge with SLR Adaptive Capacity: Medium* Short-term solutions exist for flood protection (e.g., sandbags), but longer-term adaptation is more difficult.
Coastal Erosion Sensitivity: Not exposed	*Coastal Erosion Adaptive Capacity: Not exposed*

Historical, Tribal Cultural, and Archaeological Resources	
SLR Sensitivity: High Chronic flooding could limit access to, damage, or destroy historical, tribal cultural, and archaeological resources.	*SLR Adaptive Capacity: Low* Because these assets are critical for their historic and cultural value, they are not easily replaced (and in some cases irreplaceable), and repairs could be difficult and/or costly.
Storm Surge with SLR Sensitivity: High Periodic flooding from storms could damage or destroy these resources.	*Storm Surge with SLR Adaptive Capacity: Medium* Protective measures against storm-based damage and flooding should be in place, though individual asset managers and maintenance staff are directly responsible for these measures. In the past, the City has been able to perform repairs-in-kind or rebuilds to flood-damaged assets (e.g., adobes) (Consultation with City of San Diego Historic Preservation Planning, 2019). Historical structures could be retrofitted or upgraded in accordance with Secretary of the Interior's Standards for the Treatment of Historic Properties.
Coastal Erosion Sensitivity: High Coastal erosion could threaten the ability of historical, tribal cultural, or archaeological resource to remain in-situ, which could result in relocation or loss of the asset.	*Coastal Erosion Adaptive Capacity: Low* Because these assets are critical for their historic and cultural value, they are not easily replaced (and in some cases irreplaceable), and repairs could be difficult and/or costly. Moving an asset is not always possible for assets that are part of the physical landscape and would have particularly negative impacts on resources that have place-based significance.

Additional Asset Vulnerability to Precipitation-driven Flooding

The City found that, within the additional asset category, only recreation centers and historical, tribal cultural, and archaeological resources face exposure to precipitation-driven flooding. Historic, tribal cultural, and archaeological resources were found to be highly vulnerable. This is due to these assets' high exposure (eight are within the 100-year floodplain) and high sensitivity (flooding could damage or destroy resources) to precipitation. However, even though libraries and City buildings were not found to be located within the FEMA floodplains, City staff indicated that many City-owned facilities are susceptible to water intrusion and damage from rain events (Consultation with City of San Diego Planning Department, 2019).

The results of the vulnerability assessment of additional asset types to precipitation-driven flooding are shown in Table 69. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to precipitation-driven flooding. Table 70 provides the rationale for the sensitivity and adaptive capacity scores.

Table 69. Vulnerability of Additional Critical Asset Types to Precipitation-driven Flooding

	Rec Centers	Libraries	City Buildings	Historical, Tribal Cultural, and Archaeological Resources
Exposure	Medium	Not exposed	Not exposed	High
Sensitivity	Medium	N/A	N/A	High
Adaptive Capacity	Medium	N/A	N/A	Medium
Vulnerability	Medium	N/A	N/A	High

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Additional Asset Exposure to Precipitation

No libraries or City buildings lie in the FEMA floodplains; recreation centers and historical, tribal cultural, and archaeological resources may be exposed to precipitation-driven flooding (Figure 46). There are nineteen historical, tribal cultural, and/or archaeological resources that face exposure from precipitation-driven flooding. Eight of these resources lie in the 100-year floodplain, while eleven resources lie in the 500-year floodplain.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to precipitation-driven flooding.

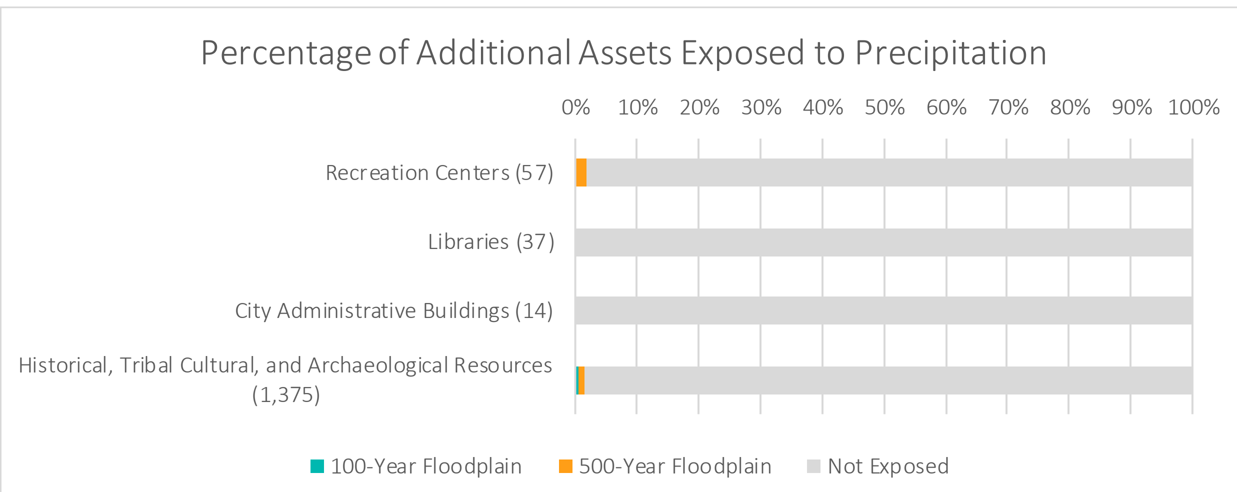

Figure 46. Additional critical assets exposed to precipitation. The value after each asset name indicates the asset count. All assets in the 100-year floodplain also lie in the 500-year floodplain; the orange colored bar for the 500-year floodplain shows assets that are outside the 100-year floodplain but experience flooding under more extreme precipitation events.

Additional Asset Sensitivity and Adaptive Capacity to Precipitation-driven Flooding

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of recreation centers and historical, tribal cultural, and archaeological resources to precipitation. The results of this analysis are presented in Table 70.

Table 70. Sensitivity and Adaptive Capacity of Additional Critical Asset Types to Precipitation-driven Flooding

Recreation Centers	
Precipitation Sensitivity Rating: Medium Roofs have leaked at recreation centers in previous storm events (City of San Diego, 2019f; City of San Diego, 2017c). Flooding in buildings could lead to costly damage (e.g., flooding at the MLK Recreation Center and racquetball court in the February 2017 storms cost $150,000) (City of San Diego, 2017b).	*Precipitation Adaptive Capacity Rating: Medium* Short-term solutions exist for flood protection (e.g., sandbags), but longer-term adaptation is more difficult.
Historical, Tribal Cultural, and Archaeological Resources	
Precipitation Sensitivity Rating: High Flooding could damage or destroy irreplaceable resources.	*Precipitation Adaptive Capacity Rating: Medium* Protective measures against precipitation-based damage and flooding should be in place, though individual asset managers and maintenance staff are directly responsible for these measures. In the past, the City has been able to perform repairs-in-kind or rebuilds to flood-damaged assets (e.g., adobes) (Consultation with City of San Diego Historic Preservation Planning, 2019). Historical structures could be retrofitted or upgraded in accordance with Secretary of the Interior's Standards for the Treatment of Historic Properties.

Additional Asset Vulnerability to Heat

The City found that all additional critical asset types face some level of exposure to heat, with recreation centers and historical, tribal cultural, and archaeological resources showing medium vulnerability.

The results of the vulnerability assessment of additional critical asset types to heat are shown in Table 71. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to heat. Table 72 provides the rationale for the sensitivity and adaptive capacity scores.

Table 71. Vulnerability of Additional Critical Asset Types to Heat

	Rec Centers	Libraries	City Buildings	Historical, Tribal Cultural, and Archaeological Resources
Exposure	High	Medium	Medium	High
Sensitivity	Low	Low	Low	Medium
Adaptive Capacity	High	High	High	Medium
Vulnerability	Medium	Low	Low	Medium

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Additional Asset Exposure to Heat

The heat island scenarios are represented as zones with scores of 0 to 100+, with higher scores denoting hotter areas (CalEPA, 2019).[51] A score of zero indicates that there is no difference in temperature over time between an urban Census tract and nearby upwind rural reference points. A score of 100 indicates that there is a difference of 7.5 degrees Fahrenheit (approx. 4.2 degrees Celsius) between these tracts over 24 hours.

In San Diego, coastal areas are relatively cooler than inland areas due to the moderating impacts of the ocean and offshore winds. This coastal effect dominates the urban heat island effect in the City.

Almost all individual additional critical assets may face some level of exposure to heat, as shown in Figure 47. One recreation center and nineteen historical, tribal cultural, and archaeological resources do not face exposure to extreme heat. Most assets face exposure at the lower heat ratings, in urban heat island index zones scoring between 0 and 40.

Historical, tribal cultural, and archaeological resources contain five assets potentially exposed to extreme heat at the 80 to 100 heat index range. There is one recreation center also exposed at this high level. Over ten percent of libraries are potentially exposed to extreme heat at the 60 to 80 heat index range.

[51] The urban heat island index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period. To estimate the total number of degrees Fahrenheit per day, divide the Index by 24 hours and multiply by 1.8 degrees. Higher scores denote hotter areas.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the heat levels.

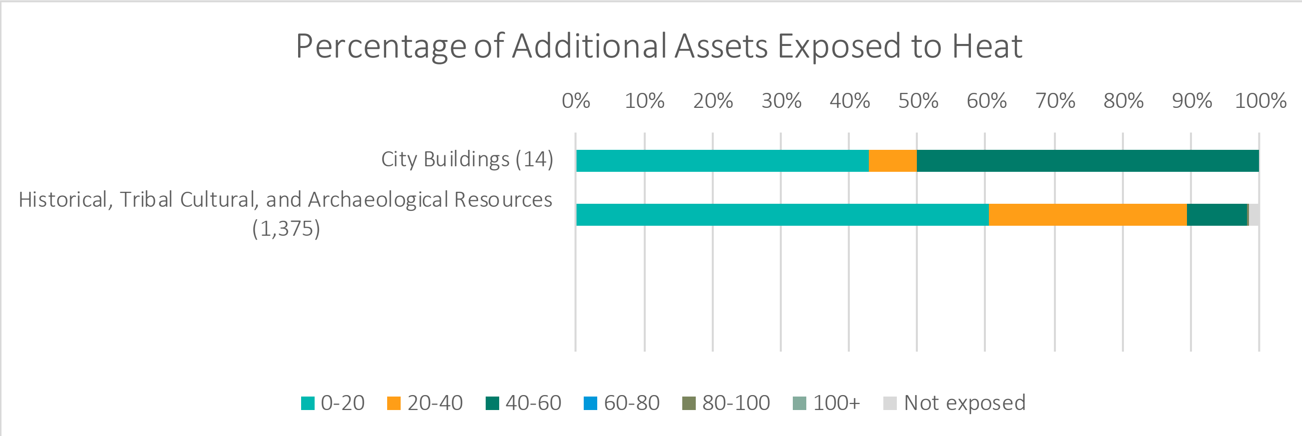

Figure 47. Additional critical assets exposed to extreme heat. The value after each asset name indicates the asset count. The colored bars represent exposure to different ranges in the UHI index, with higher UHI values denoting hotter areas and therefore increased exposure to heat.

Additional Asset Sensitivity and Adaptive Capacity to Heat

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of all additional critical asset types to heat. The results of this analysis are presented in Table 72.

Table 72. Sensitivity and Adaptive Capacity of Additional Critical Asset Types to Heat

Recreation Centers	
Heat Sensitivity Rating: Low Thermal stress could cause wear on building materials and place an increased load on mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011).	*Heat Adaptive Capacity Rating: High* Tree plantings are an option with multiple co-benefits (Consultation with City of San Diego Sustainability Department, 2019) While several newer recreation centers have air conditioning and are energy efficient, most do not have air conditioning or energy efficient systems (Consultation with City of San Diego Parks and Recreation Department, 2019).
Libraries	
Heat Sensitivity Rating: Low Thermal stress could cause wear on building materials and place an increased load on mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011).	*Heat Adaptive Capacity Rating: High* Almost all libraries have air conditioning, and most are energy efficient (Consultation with City of San Diego Facilities, 2019).
City buildings	
Heat Sensitivity Rating: Low Thermal stress could cause wear on building	*Heat Adaptive Capacity Rating: High* New buildings (built within the last five to eight

materials and place an increased load on mechanical and cooling equipment, leading to higher energy costs and potentially damaging electrical equipment (USAID, 2014; USGBC, 2011).	years) are guaranteed to be energy efficient. New City design standards require all buildings to either be LEED certified or energy efficient. All buildings built before this standard would likely not be energy efficient (Consultation with City of San Diego Facilities, 2019).
Historical, Tribal Cultural, and Archaeological Resources	
Heat Sensitivity Rating: Medium Warmer temperatures and higher humidity have the potential to damage historic structures and materials (USAID, 2014).	*Heat Adaptive Capacity Rating: Medium* Historical, tribal cultural, and archaeological resources may be difficult and/or costly to repair, replace, or move. However, historical structures could be retrofitted or upgraded in accordance with Secretary of the Interior's Standards for the Treatment of Historic Properties.

Additional Asset Vulnerability to Wildfire

The City found that all additional critical asset types show medium to high vulnerability to wildfire. All include assets within the City's brush management zone (the highest potential exposure level). Recreation centers, libraries, and City buildings show medium sensitivity to wildfire, as many of these buildings are built with fire-resistant materials. Historical, tribal cultural, and archaeological resources show high sensitivity to wildfire, since many of these resources are not fire-resistant and could be lost if severely damaged.

The results of the vulnerability assessment of additional critical asset types to wildfire are shown in Table 73. The following sections provide greater detail on the exposure, sensitivity, and adaptive capacity of these asset types to wildfire. Table 74 provides the rationale for the sensitivity and adaptive capacity scores.

Table 73. Vulnerability of Additional Critical Asset Types to Wildfire

	Rec Centers	Libraries	City Buildings	Historical, Tribal Cultural, and Archaeological Resources
Exposure	High	High	High	High
Sensitivity	Medium	Medium	Medium	High
Adaptive Capacity	High	High	High	Low
Vulnerability	Medium	Medium	Medium	High

Note: Exposure scores are based on the best available climate science, the interpretation of this science in the context of the timeframes when impacts may occur, risk management considerations, and asset location data to identify spatial overlap between critical City assets and climate hazards within the City limits. Sensitivity and adaptive capacity scores are based on information from literature reviews and interviews with City department staff and represent generalizations for asset types, rather than individual assets. More information on the scoring methodology can be found in Table 8, Table 9, and Table 10. Green shaded cells in the table indicate good candidates for consideration of adaptation strategies.

Additional Asset Exposure to Wildfire

All additional asset types may be exposed to wildfire (Figure 48); however, less than half of all assets within each asset type

Wildfire Hazard Zones for San Diego

High: Native vegetation and 100-foot setback zones

Medium: 300-foot setback zone

Low: Fire hazard zone outside native vegetation zone and setbacks may be exposed to wildfire. Of exposed assets, twelve to sixteen percent face high exposure to wildfire, five to twenty-eight percent face medium exposure, and seven to nine percent face low exposure.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the fire hazard zones.

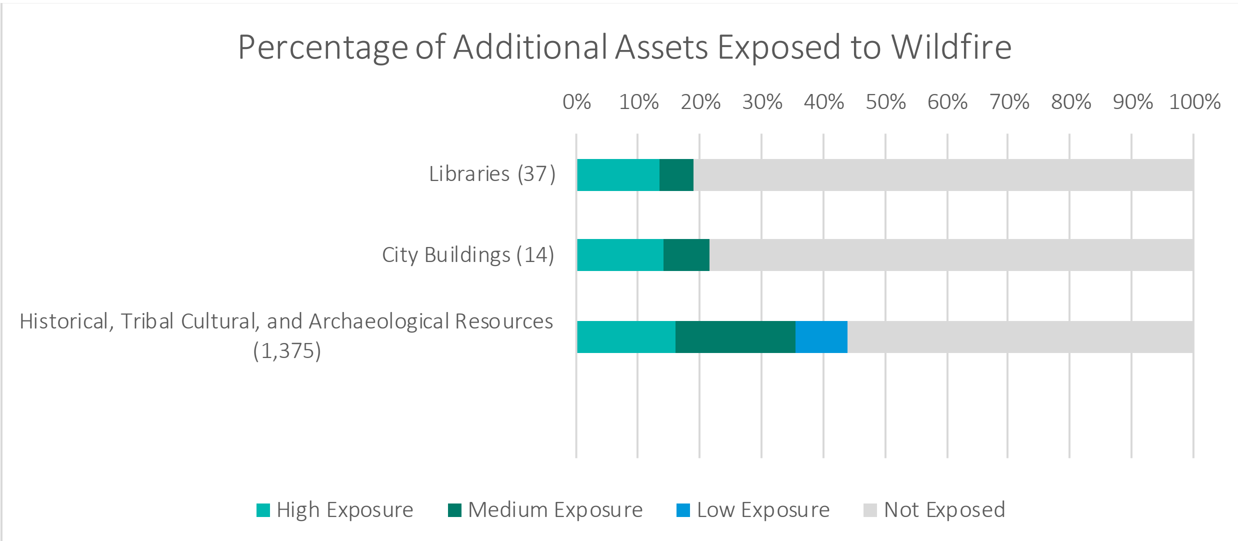

Figure 48. Additional critical assets exposed to wildfire. The value after each asset name indicates the asset count.

Additional Asset Sensitivity and Adaptive Capacity to Wildfire

Based on the exposure assessment, the City analyzed the sensitivity and adaptive capacity of all additional critical asset types to wildfire. The results of this analysis are presented in Table 74.

Table 74. Sensitivity and Adaptive Capacity of Additional Critical Asset Types to Wildfire

Recreation Centers	
Wildfire Sensitivity Rating: Medium Wildfires could directly damage buildings and increase deterioration via increased particulate matter and smoke (USAID, 2014). Most recreation centers are of masonry construction with fire-resistant roofs (Consultation with City of San Diego Parks and Recreation Department, 2019).	*Wildfire Adaptive Capacity Rating: High* Most recreation centers have defensible space.
Libraries	
Wildfire Sensitivity Rating: Medium Wildfires could directly damage buildings and could accelerate building material deterioration due to increased smoke and particulate matter (USAID, 2014). However, only one library—Logan Heights—is made with fire-susceptible material (City of San Diego Facilities, 2019).	*Wildfire Adaptive Capacity Rating: High* All buildings have defensible space (City of San Diego Facilities, 2019).

City buildings	
Wildfire Sensitivity Rating: Medium Wildfires could directly damage buildings and could accelerate building material deterioration due to increased smoke and particulate matter (USAID, 2014). However, no City buildings are made with fire-susceptible material.	*Wildfire Adaptive Capacity Rating: High* All buildings have defensible space (City of San Diego Facilities, 2019).

Historical, Tribal Cultural, and Archaeological Resources	
Wildfire Sensitivity Rating: High Historical resources include assets that are constructed with flammable materials. Many historical resources have a wooden exterior, which makes them more susceptible to fire. Wildfires, efforts to extinguish them, and their aftermath (e.g., runoff and erosion) could damage or destroy irreplaceable historical, tribal cultural, and archaeological resources. In previous events, this has been costly, but may be covered by insurance, allowing for repair when possible (City of San Diego, 2007).	*Wildfire Adaptive Capacity Rating: Low* Wildfire threat could be mitigated to some extent through use of defensible space and other interventions such as planting low-fuel native vegetation around above-ground archaeological resources, fire sprinklers in buildings, and materials could be replaced in-kind when damage is not extensive. Some but not all historical, tribal cultural, and archaeological resources have defensible space (Consultation with City of San Diego Historic Preservation Planning, 2019). Destruction of a historical resource by wildfire would result in an irreplaceable loss to the City's history and culture.

Non-City-Owned Resources

In addition to the critical City assets discussed thus far, this assessment also considered the exposure of certain non-City asset types to give a more holistic view of climate change risks. Specifically, an exposure assessment of state highways and freeways as well as privately owned land was included to provide a more comprehensive view of how climate hazards may impact the City. Vulnerability scores were not calculated for these assets, as the City does not have full insight into the sensitivities and adaptive capacities of assets it does not manage.

State-Owned

Though state highways and freeways are not owned or managed by the City, these assets are part of the transportation infrastructure network within the City and were included in this vulnerability assessment to provide a more holistic view of the transportation network serving the City. Like bridges and major arterials (discussed under the Transportation and Storm Water Vulnerability Findings section above), these two asset types are broken down into roadway segments as defined in the City's asset management system.

The results of the exposure assessment for state highways and storm water are shown in Table 75. "N/A" indicates that the assets were not found to be exposed to the hazard. The City found that state highways face exposure to all hazards, and freeways face exposure to all hazards except coastal erosion.

Table 75. Exposure of State Highways and Freeways to Climate Change Hazards[52]

	SLR	Storm Surge with SLR	Coastal Erosion	Precipitation	Heat	Wildfire
State Highways	High	High	High	High	High	High
Freeways	High	High	N/A	High	High	High

State Highways and Freeways Exposure to Coastal Hazards

Coastal hazards include sea level rise, storm surge, and erosion. Daily flooding was used to estimate exposure to chronic inundation and represents the extent of flooding that would occur at high tide on average each day assuming each sea level rise scenario. Storm surge flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm assuming each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

Sea Level Rise (SLR) Projections for San Diego

2030: 0.25 m

2050: 0.5 to 0.75 m

2100: 1.0 to 2.0 m

Two percent of freeway assets may be exposed to sea level rise while nearly twenty percent of state highways may be exposed to sea level rise; however, there are significant local exposure concerns in some coastal neighborhoods (Figure 49).

A few more state highway and freeway critical assets face exposure to flooding with storm surge, but the proportion still stays below 5 percent, with a total of up to 103 state highway and freeway road segments exposed to a potential 2100 storm surge event (Figure 50). In a storm surge scenario, assets become exposed across a broader spectrum of sea level rise ranges. Neither state highways nor freeways are exposed to cliff erosion (Figure 51). As Figure 52 shows, four state highway segments may be exposed to beach erosion.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the coastal hazard scenarios.

[52] The exposure scores were calculated using a combination of spatial asset data provided by the City of San Diego or SanGIS and the best available spatial projections and localized modeling for the chosen climate hazard scenarios. The scores reported here do not reflect the exposure of specific, individual assets, but rather the highest asset type exposure.

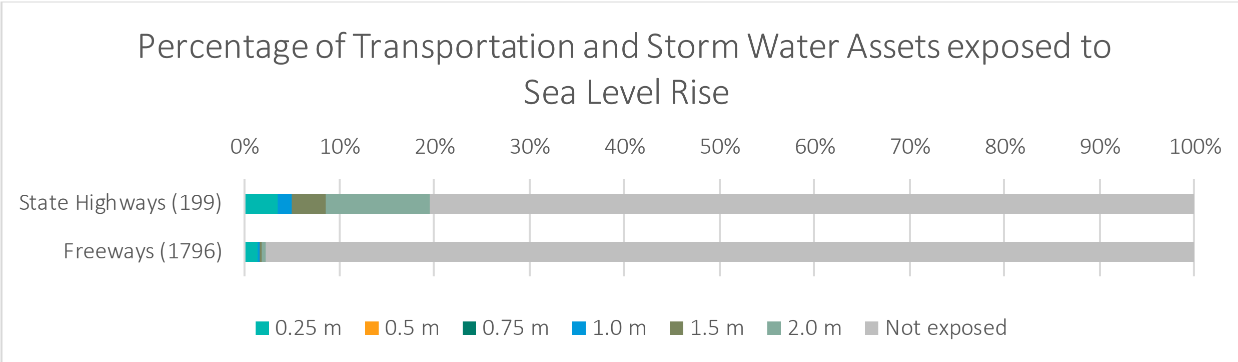

Figure 49. State highway and freeway critical assets exposed to sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario.

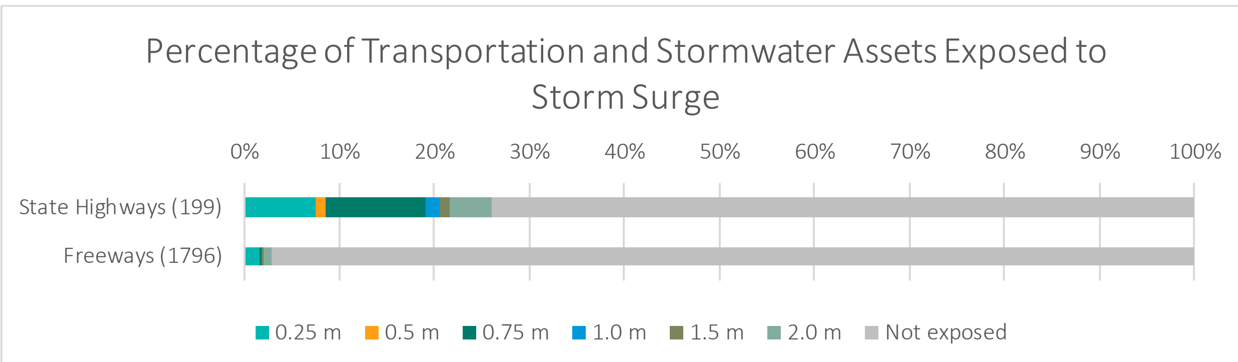

Figure 50. State highway and freeway critical assets exposed to storm surge with sea level rise; this includes the 100-year storm on top of sea level rise. The value after each asset name indicates the asset count. The colored bars for each increment of sea level rise show how many additional assets become inundated in each sea level rise scenario. Assets would be exposed to storm surge prior to being exposed to average daily flooding, so more assets in this graph tend to be exposed under lower sea level rise amounts.

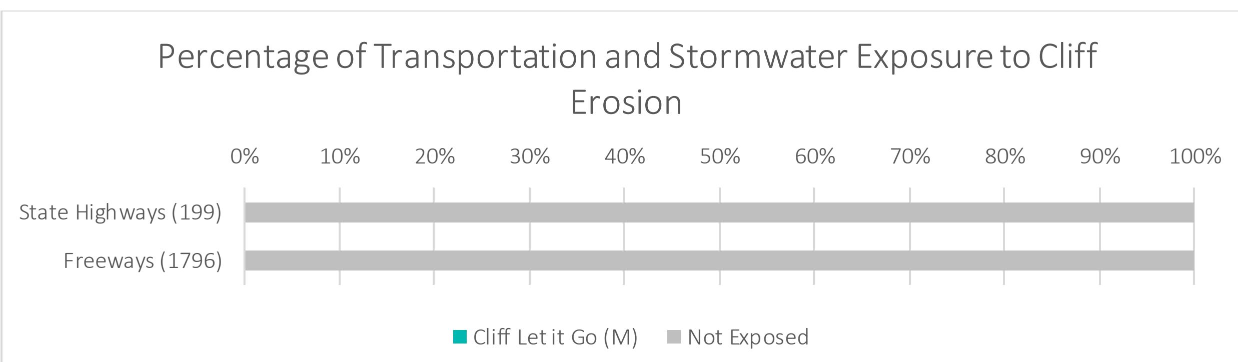

Figure 51. State highway and freeway critical assets exposed to cliff erosion. The value after each asset name indicates the asset count. "Cliff let it go" represents the number of assets exposed to flooding if the City does not implement coastal armoring and allows cliff retreat and erosion.

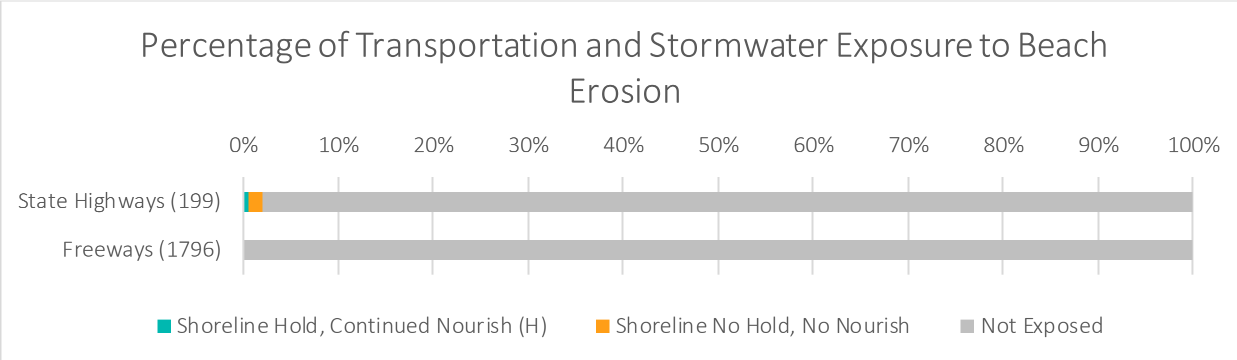

Figure 52. State highway and freeway critical assets exposed to beach erosion. The value after each asset name indicates the asset count. "Shoreline Hold, Continued Nourish" represents the number of assets exposed to flooding if the City continues beach nourishment and sea wall repair, while "Shoreline No Hold, No Nourish" represents the number of assets exposed if the City were to stop beach nourishment and seawall repair.

State Highway and Freeway Exposure to Precipitation-driven Flooding

Both asset types have assets within the 100- and 500-year floodplains, though these exposed assets represent a relatively small proportion of all state highway and freeway assets (Figure 53). There are 360 freeway segments that lie in a floodplain, with about half of those lying in the 100-year floodplain. Like bridges, state highways may be less exposed to precipitation-driven flooding, but most of the assets that are exposed lie in the 100-year floodplain.

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to precipitation-driven flooding.

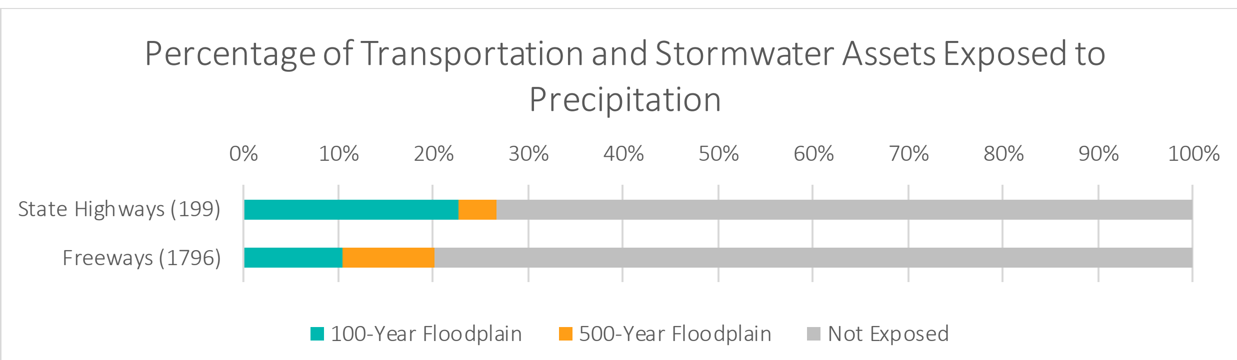

Figure 53. State highway and freeway critical assets exposed to precipitation. The value after each asset name indicates the asset count. All assets in the 100-year floodplain also lie in the 500-year floodplain; the orange colored bar for the 500-year floodplain shows assets that are outside the 100-year floodplain but experience flooding under more extreme precipitation events.

State Highways and Freeways Exposure to Heat

The City estimated that both state highway and freeway asset types face exposure to heat, as heat exposure is ubiquitous throughout the City. However, the City did not quantitatively analyze heat exposure for state highway and freeway assets, as segments of these road types crossed between heat island zones, which led to double-counting segments and therefore would have resulted in an inaccurate count.

State Highways and Freeways Exposure to Wildfires

The City found that both state highway and freeway asset types are exposed to wildfires (Figure 54). Because these segments are long enough to overlap with multiple different fire hazard zones, only the percentage of state highway and freeway segments exposed to the highest level of exposure is shown.

> **Wildfire Hazard Zones for San Diego**
>
> High: Native vegetation and 100-foot setback zones

See Appendix C: Exposure Data for more detailed information on the number of assets exposed to each of the fire hazard zones.

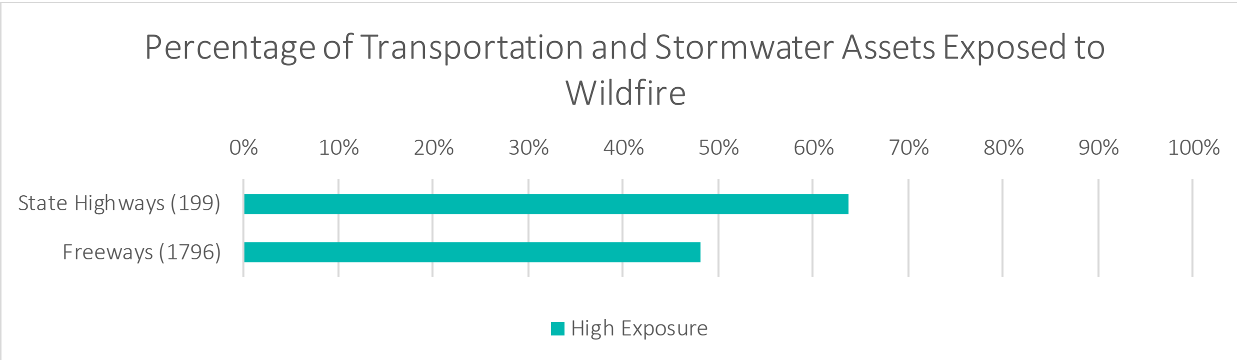

Figure 54. State highway and freeway assets exposed to wildfire. The value after each asset name indicates the asset count.

Non-City-Owned Assets

The City also reviewed the exposure of private land use types to gain a more comprehensive view of how climate change might impact various sectors in the City. Vulnerability scores were not calculated for these assets, as the City does not have full insight into the sensitivities and adaptive capacities of assets it does not manage.

Assets in the "non-city-owned assets" category would also face exposure to climate change hazards. The City identified seventy-two unique land use types and grouped them into seventeen categories: agricultural, commercial, community, cemetery, entertainment, health, hotel/motel, industrial, institutional, marina docks, office space, open space, residential, restaurant, rural, not defined, and vacant. For this exposure assessment, each parcel was assigned one or more land use types based on the tax assessors' land use code (Table 76).

Table 76. Private Land Use Types. Source: Tax Assessor's Database

Category	Land Use Types
Agricultural	1 to 10 acres non-irrigated; 41 to 160 acres non-irrigated; 161 to 360 acres non-irrigated; 361 acres and up non-irrigated; agricultural preserve (under contract); avocado; citrus; irrigated crops other vegetable, floral, feeding (hay or seed crops); livestock; misc. agricultural; trees misc. (other than citrus or avocado)
Commercial	Auto sales/service agency; automotive repair garages; car wash; community shopping center; garage parking lot/used car; generic commercial office retail 1-3 stories; generic radio station/bank/misc.; grocery/drug store large chain

	generic; neighborhood shopping center; regional shopping center; service station—generic
Community	Church; church rectory, parking and other church related use; co-op generic; meeting hall, gym—generic; public building (school, firehouse, library, etc.); theater—generic
Cemetery	Cemetery; mausoleum; mortuary
Entertainment	Bowling alley; golf course
Health	Generic—medical/dental office; hospital; rest home/convalescent hospital
Hotel/motel	Hotel/motel
Industrial	Factory/heavy manufacturing; factory/light manufacturing; industrial condos; misc. industrial/special land; natural resources—mining, extractive, processing cement/silica products, rock and gravel; storage bulk chemical/oil refinery; warehouse—processing/storage/distribution
Institutional	Institutional
Marina docks	Marina docks
Office space	Generic—four- and more story office building; office condominiums
Open space	Open space
Residential	Condominiums and other residential classifications; duplex—generic; manufactured home in park—not specified; single family residential—generic; time share generic; trailer park
Restaurant	Restaurant/night club/tavern
Rural	Rural land other
Not defined	Information parcel—generic; miscellaneous/special; multiple 2 to 4 units—generic; multiple 5 to 15 units—generic; multiple 16 to 60 units—generic; multiple 61 units and up—generic; non-taxable; special—sliver, small parcel
Vacant	Institutional—vacant; irrigated farm vacant water available; vacant industrial; vacant land commercial; vacant recreational; vacant residential—generic; vacant taxable govt. owned property

The City is unable to assess the sensitivity and adaptive capacity of non-City-owned assets to climate change hazards since the specifics of the building construction, maintenance, emergency plans, and other details are unknown. However, assessing exposure to climate change hazards provides insights into the potential scope of future concerns.

The City has assessed the exposure of private land to sea level rise, storm surge with sea level rise, coastal erosion, precipitation, and wildfire. Extreme heat exposure was not assessed in this study because the entire City faces increasing heat exposure over time. Temperatures would continue to be lowest along the coastline and increase farther inland; however, all buildings may need to consider more energy efficient air conditioning and passive cooling strategies (such as use of trees and vegetation) to adapt to rising temperatures. Land that is primarily open space (i.e., agricultural, golf courses, privately owned open space, and rural land) would benefit from further exploration of the impacts of heat on ecosystems present on the land. Similarly, because extreme heat can impact public health and social equity, it would be beneficial to assess community-level extreme heat impacts and social equity considerations.

For all exposure estimates, it is worth noting that the number of exposed parcels reflects whether any part of the parcel overlapped with a hazard. Exposure of a parcel of land does not necessarily mean that the buildings within the parcel would be exposed. For example, a parcel may extend to the coastline and therefore be exposed to sea level rise, but the buildings are all situated on the inland side of the parcel.

The land use category with the greatest exposure to sea level rise is marina docks: due to their location on the waterfront, ninety-one percent of these parcels are currently exposed (Figure 55). By definition, marina docks are at the waterfront and exposed to the sea. Four to six percent of entertainment, hotel and motel, and restaurant parcels may be exposed to sea level rise by 2030. The number of exposed parcels is not expected to increase significantly between 2030 and 2050.

Under the high emissions scenario, between five percent and sixty-two percent of hotel and motel parcels may be exposed to sea level rise in 2100. Up to eleven percent of entertainment and restaurant parcels may also be exposed to sea level rise in 2100. Other land use categories may not experience significant exposure between now and 2100 (about five percent or less of the remaining asset types may be exposed in 2100).

Up to 5,550 residential parcels may face exposure to sea level rise and almost 9,000 residential parcels may face exposure to storm surge with sea level rise in 2100. While this is a low percentage of the overall housing stock, it represents a significant vulnerability for those homeowners.

With storm surge considered in combination with sea level rise, the most notable difference in exposure is that a large number of hotel and motel parcels may be exposed much earlier: between five and fifty-eight percent of these parcels may face exposure by 2050 (compared with up to five percent by 2050 with sea level rise alone) (Figure 56). Almost ninety-five percent of marina dock parcels may be exposed to storm surge by 2030; most of these already face exposure.

Very few private parcels are exposed to cliff erosion (Figure 57). There are no cemetery, health, marina docks, office space, open space, or rural land parcels that face exposure, and a very small percentage (less than five percent) of other land use categories face exposure to cliff erosion. About 2,500 residential parcels face exposure to cliff erosion assuming 2.0 meters of sea level rise (which is the upper range for 2100).

Similarly, very few parcels are exposed to beach erosion, even if the City were to stop beach nourishment and seawall repair (Figure 58). Community, cemetery, health, industrial, marina dock, office space, open space, and rural land parcels face no exposure to beach erosion, and other land use categories face very small (less than 5 percent) exposure to beach erosion.

All land use categories face some level of exposure to precipitation-based flooding. The land use category facing the greatest proportional exposure is marina docks: about eighty-five percent of marina dock parcels lie in the FEMA 100-year floodplain, and almost ninety percent lie in the 500-year floodplain (Figure 59). The next-highest exposure is faced by entertainment parcels, of which more than thirty percent lie in the 100-year floodplain. Over ten percent of cemetery, industrial, and institutional parcels lie in the 100-year floodplain, and over ten percent of hotel and motel and restaurant parcels lie in the 500-year floodplain. Less than ten percent of the remaining land use categories lie in the 100-year or 500-year floodplain.

All land use categories except marina docks face some level of exposure to wildfire. Rural land faces the highest relative exposure to wildfire, with nearly ninety percent of parcels facing high exposure. Hotel/motel parcels face the lowest relative exposure to wildfire, with only four percent of parcels facing high exposure (Figure 60).

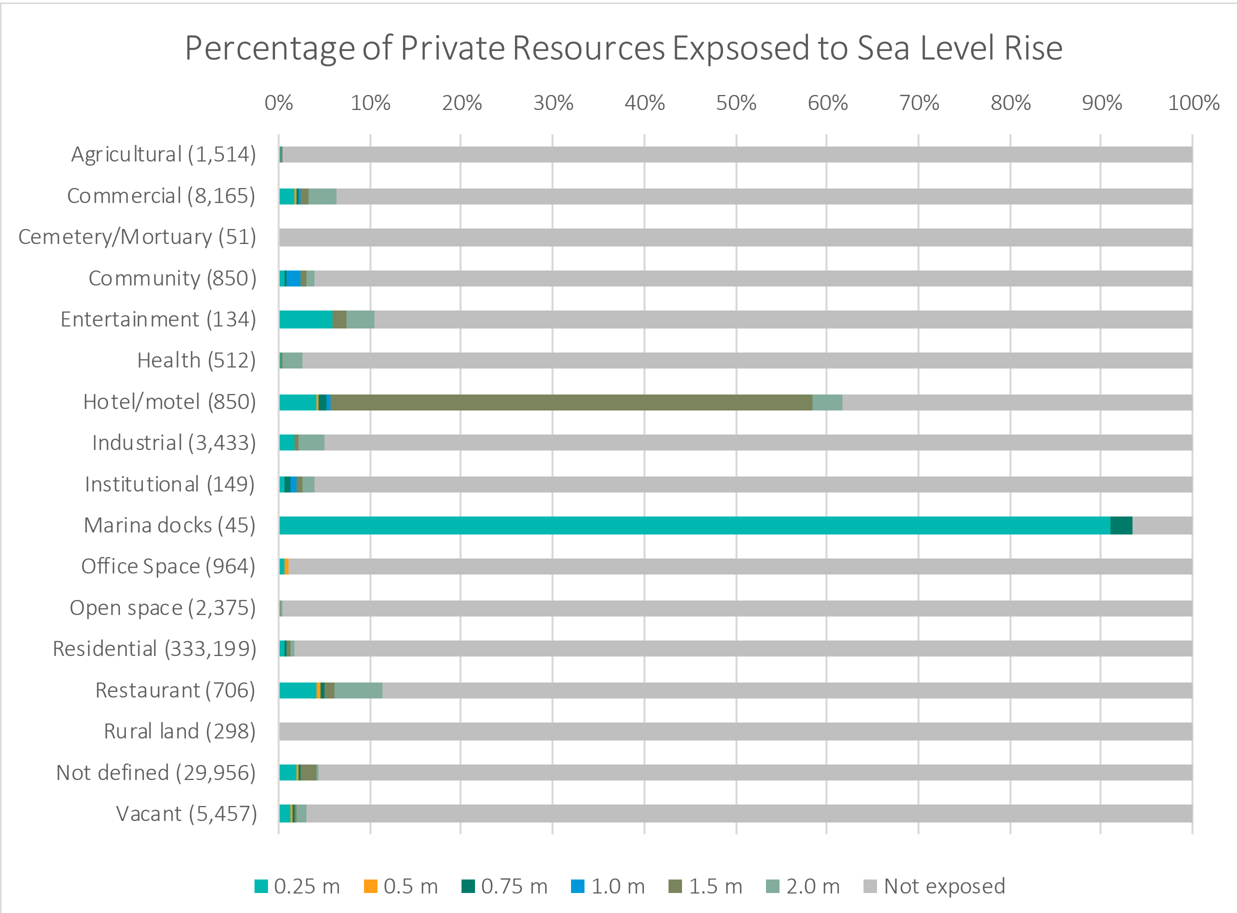

Figure 55. Private resources exposed to sea level rise. The value after each land use category indicates the total number of parcels of that land use category. The colored bars for each increment of sea level rise show how many additional parcels become inundated in each sea level rise scenario.

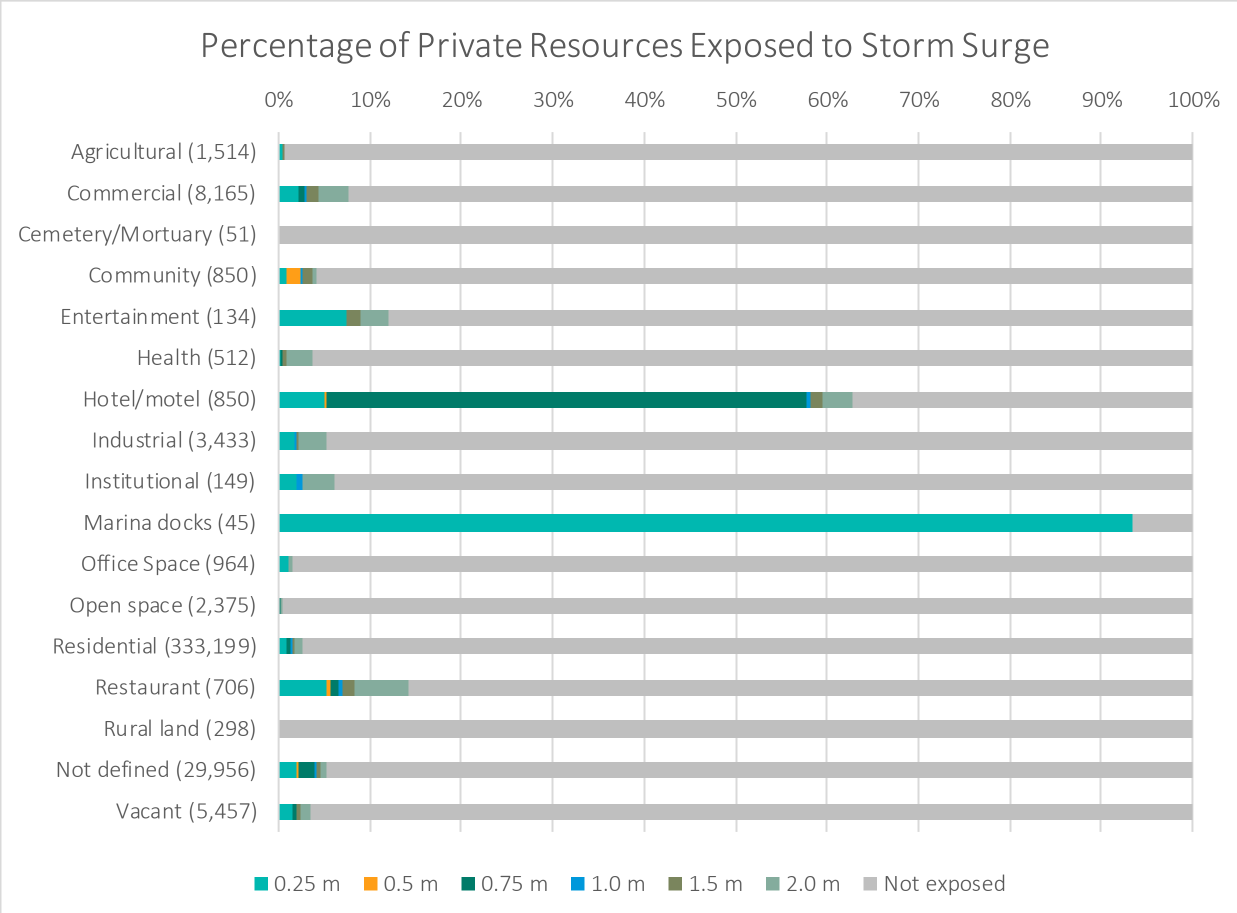

Figure 56. Private resources exposed to storm surge with sea level rise; this includes the 100-year storm on top of sea level rise. The value after each land use category indicates the total number of parcels of that land use category. The colored bars for each increment of sea level rise show how many additional parcels become inundated in each sea level rise scenario.

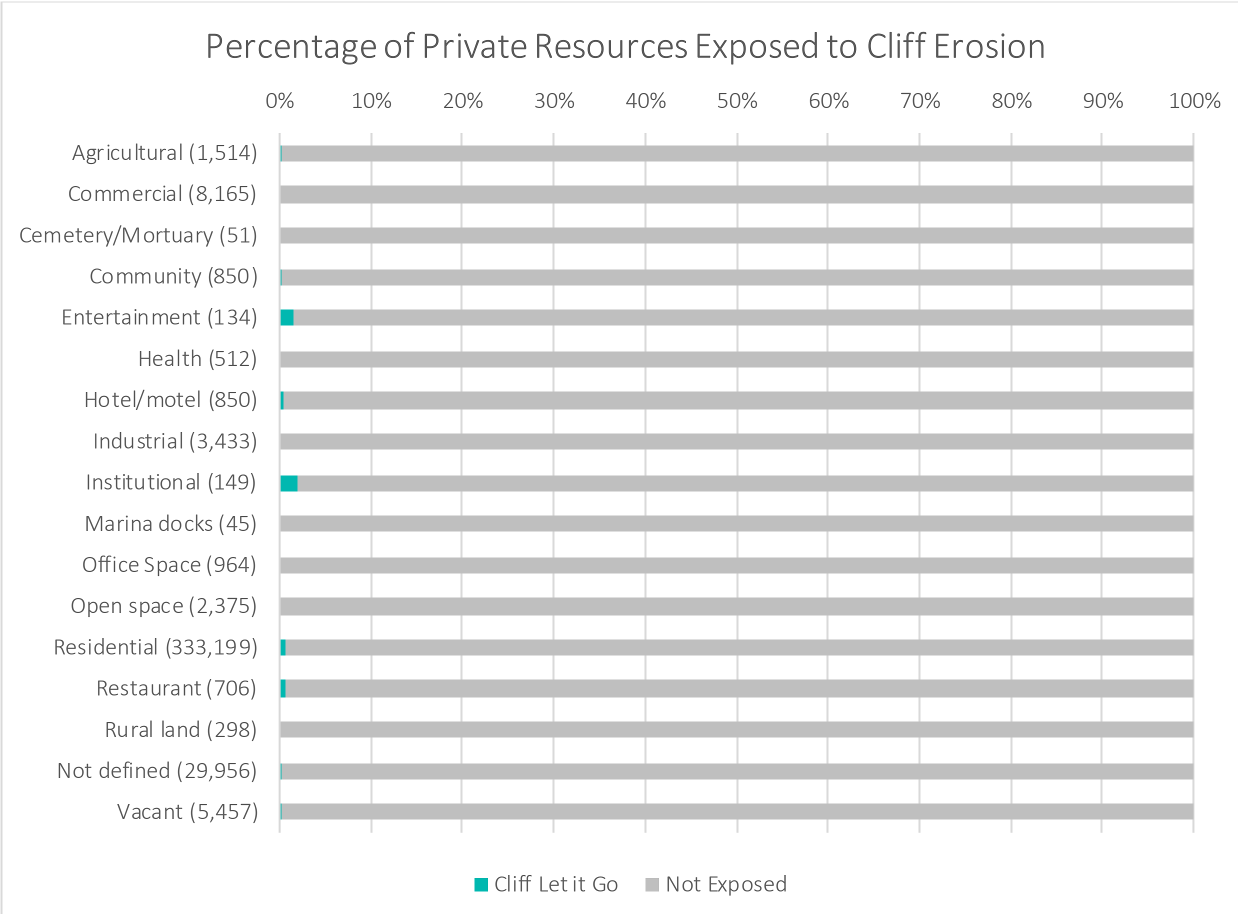

Figure 57. Private resources exposed to cliff erosion. The value after each land use category indicates the parcel count. "Cliff Let it Go" represents the percentage of parcels exposed to flooding if the City does not implement coastal armoring and allows cliff retreat and erosion.

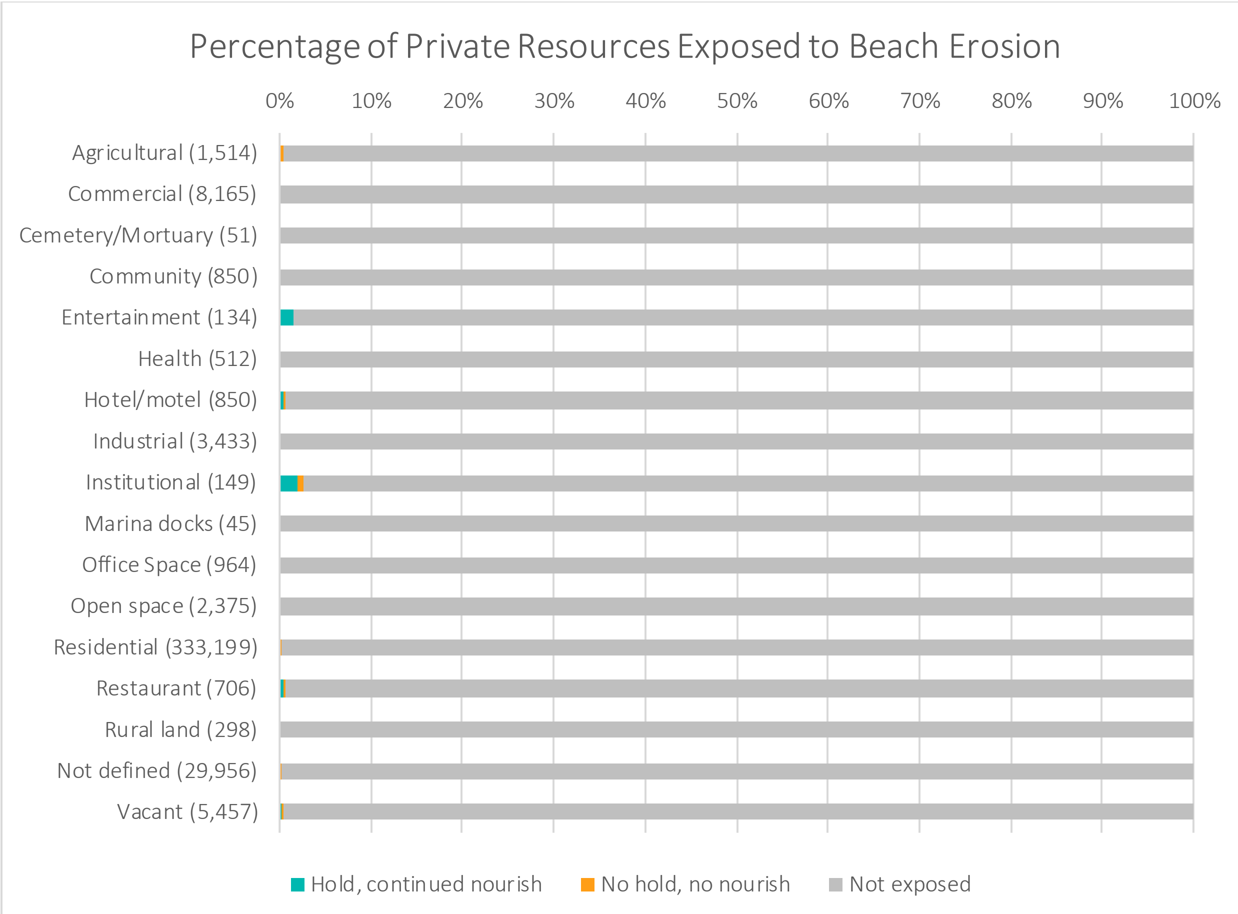

Figure 58. Private resources exposed to beach erosion. The value after each land use category indicates the parcel count. "Hold, continued nourish" represents the percentage of parcels exposed to flooding if the City continues beach nourishment and sea wall repair, while "No hold, no nourish" represents the percentage of parcels exposed if the City were to stop beach nourishment and seawall repair.

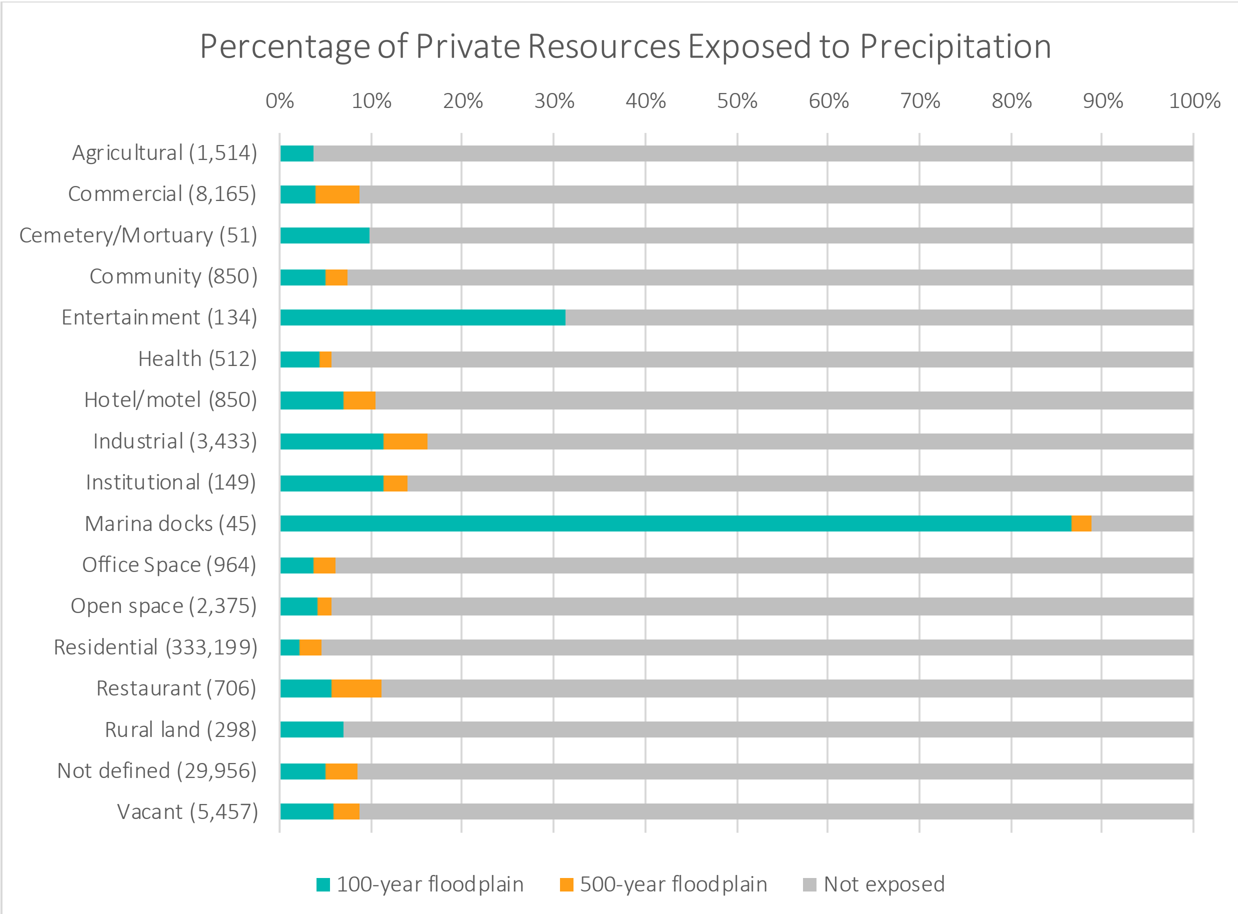

Figure 59. Private resources exposed to precipitation. The value after each land use category indicates the parcel count. All parcels in the 100-year floodplain also lie in the 500-year floodplain; the orange colored bar for the 500-year floodplain shows parcels that are outside the 100-year floodplain but experience flooding under more extreme precipitation events.

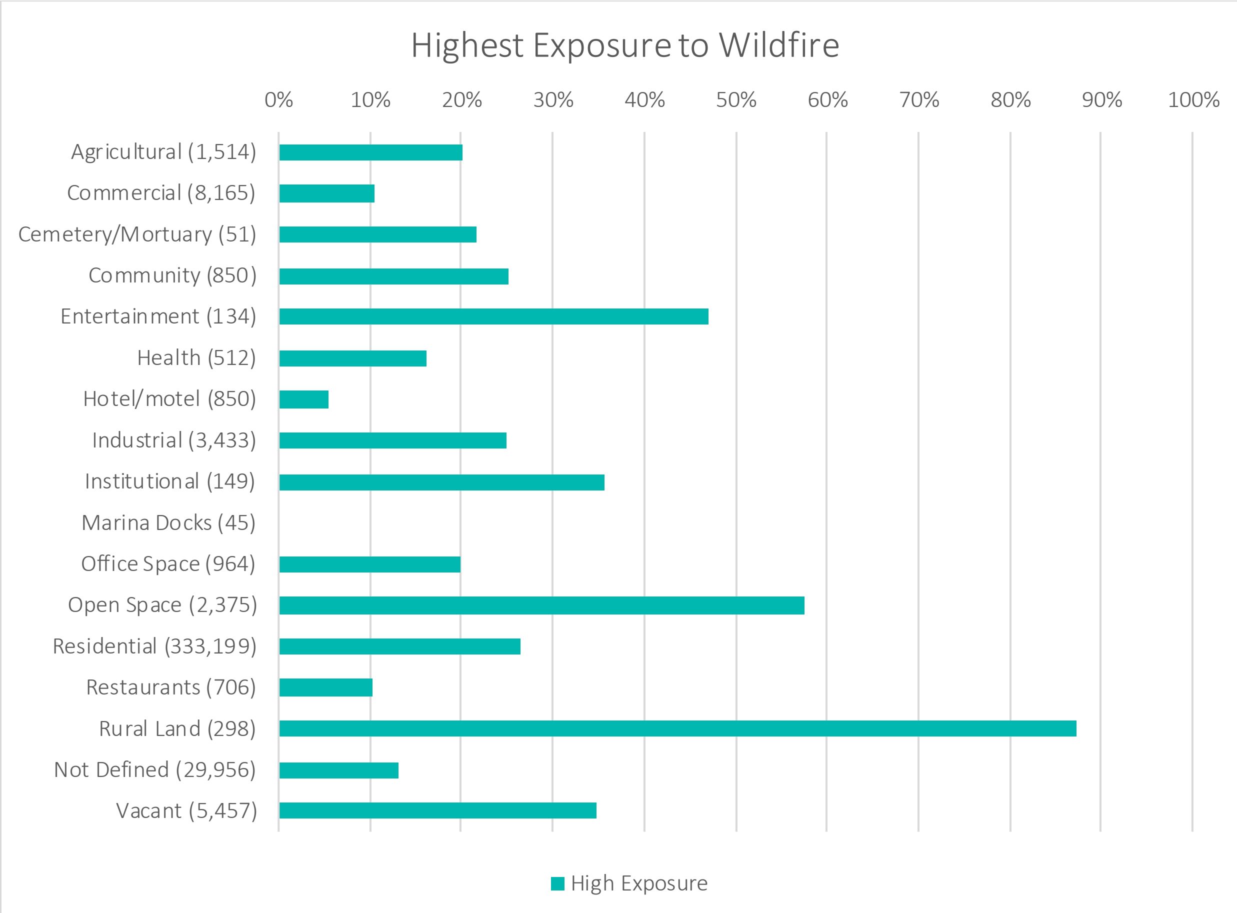

Figure 60. Private resources exposure to wildfire. The value after each land use category indicates the parcel count. Because parcels are large enough to overlap with multiple different fire hazard zones, only the percentage of parcels exposed to the highest level of exposure is shown.

Building Toward the *Climate Resilient SD Plan*

This vulnerability assessment is part of the City's overall effort to create a *Climate Resilient SD* Plan, whose goals include:

- Address climate equity by prioritizing and empowering our most vulnerable populations to climate change, with strong consideration of communities of concern;
- Raise awareness of projected/potential climate change impacts to the City;
- Gain a comprehensive understanding of the City's climate change vulnerabilities;
- Build City capacity for preventive and responsive action; and
- Identify potential climate adaptation and resilience strategies.

Based on the findings of this vulnerability assessment and consultations with stakeholders, the City identified key vulnerable asset types for inclusion in Phase 2, the detailed risk assessment. The detailed risk assessment investigated climate risk and impact consequences at the scale of individual selected assets, allowing the City to identify selected high-risk assets and develop targeted adaptation strategies. The next step in the process is for the City to develop a comprehensive *Climate Resilient SD* Plan, combining the findings of the vulnerability and risk assessment and identified adaptation strategies.

Glossary

100-year floodplain: Flood hazard areas identified by the Federal Emergency Management Agency (FEMA) that are defined as the area that will be inundated by the flood event having a one percent chance of being equaled or exceeded in any given year.

500-year floodplain: Flood hazard areas identified by FEMA that are defined as the area that will be inundated by the flood event having a 0.2-percent chance of being equaled or exceeded in any given year.

Adaptation: "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities" (California Coastal Commission, 2018).

Adaptive Capacity: "The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences" (California Coastal Commission, 2018) citing (Willows, 2003).

Assets: "People, resources, ecosystems, infrastructure, and the services they provide. Assets are the tangible and intangible things people or communities value" (US Climate Resilience Toolkit, 2019).

CNG: Compressed natural gas, which is used as a fuel for specialty fleet vehicles.

Consequence: The effect of climate change exposure on community structures, functions, and populations and on the asset owner or service providers' ability to maintain a standard condition or level of service (sometimes referred to as impacts) (CEMA and CNRA, 2012).

Drain Pump Stations: Facilities including pumps and equipment for pumping fluids from one place to another, in particular for the City, these stations are for pumping storm water and wastewater to treatment plants and outfalls.

Exposure: "The presence of people, infrastructure, natural systems, and economic, cultural, and social resources in areas that are subject to harm" (Bedsworth, 2018) citing (IPCC, 2012).

Hazard: "An event or condition that may cause injury, illness, or death to people or damage to assets" (US Climate Resilience Toolkit, 2019).

Impact: "Effects on natural and human systems that result from hazards" (US Climate Resilience Toolkit, 2019).

Outfalls: Where storm water and wastewater are discharged into bodies of water.

Sensitivity: "The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (*e.g.*, a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (*e.g.*, climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors)" (California Coastal Commission, 2018).

Resilience: "The capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption" (US Climate Resilience Toolkit, 2019).

Risk: The potential consequences if something is damaged or lost, considered together with the likelihood of that loss occurring.

Urban Heat Island (UHI): Large urban areas, especially those inland from the coast, often experience higher temperatures during hot summer months when compared to more rural communities, which is known as the urban heat island effect. This phenomenon is due to the absorption and retention of heat by pavement and buildings, in addition to a lack of coastal breezes.

Vulnerability: "The extent to which a species, habitat, ecosystem, or human system is susceptible to harm from climate change impacts. More specifically, the degree to which a system is exposed to, susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, include.ng its sensitivity, and its coping and adaptive capacity" (California Coastal Commission, 2018).

Wave runup: The height above stillwater elevation reached by a wave along a beach or structure (FEMA, 2005).

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Department Consultations

The Planning Department consulted with staff members across various City departments to better understand critical asset consequences and vulnerability. The findings associated with these citations represent the judgments based on the best information available to these individuals, who were consulted between January 2019 and February 2020, and do not reflect official departmental policies.

- City of San Diego Office of the Mayor, 2019
- City of San Diego Environmental Services Department (ESD), 2019
- City of San Diego Facilities Department, 2019
- City of San Diego Fire-Rescue Department, 2019
- City of San Diego Fleet Operations, 2019
- City of San Diego Historic Preservation Planning, 2019 and 2020

- City of San Diego Multi-species Conservation Plan (MSCP) team, 2019
- City of San Diego Parks and Recreation Department, 2019 and 2020
- City of San Diego Planning Department, 2019 and 2020
- City of San Diego Police Department, 2019
- City of San Diego Public Utilities Department (PUD), 2019 and 2020
- City of San Diego Real Estate Assets Department (READ), 2019
- City of San Diego Sustainability Department, 2019
- City of San Diego Transportation and Storm Water Department (TSWD), 2019

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- Port of San Diego
- San Diego MTS
- Scripps Institute of Oceanography
- Health and Human Services Agency
- Community Action Partnership
- County of San Diego
- U.S. Fish and Wildlife Service
- CDFW
- Coastal Conservancy
- Circulate San Diego
- Clean Tech San Diego
- San Diego Bike Coalition
- Environmental Health Coalition
- SANDAG
- UC San Diego
- San Diego Chamber of Commerce
- San Diego Gas & Electric
- San Diego Audubon
- El Dorado Properties
- San Diego Regional Airport Authority

Appendix A: Climate Data and Projections

The City of San Diego worked with ICF, a consulting firm, to conduct this vulnerability assessment. This appendix was originally a memorandum prepared by ICF to provide background information on and justification for the selected climate change scenarios used to estimate projected climate change exposure in this assessment.

Coastal Hazards

The primary threats assessed under the umbrella of coastal hazards include sea level rise, coastal flooding, and coastal erosion.

Sea Level Rise and Coastal Flooding

> Sea levels rose 0.71 feet in San Diego during the 20th century (NOAA, 2018). By the end of the 21st century, San Diego could experience another 3.6 to 10.2 feet of sea level rise.
>
> Coastal storms are projected to occur more frequently in the future, which will further exacerbate flooding along the coast.

Past and Present Conditions: Over the past century, mean global sea level has risen approximately 1.7 mm per year (about 0.07 inches per year) accelerating to a rate of 3.2 mm per year since 1993 (IPCC, 2013). From 1906 to 2017, the tide gauge at San Diego suggests a rise of approximately 2.17 mm per year (about 0.09 inches per year), approximately thirty-two percent higher than the global rate (see Figure 61) (NOAA, 2018).

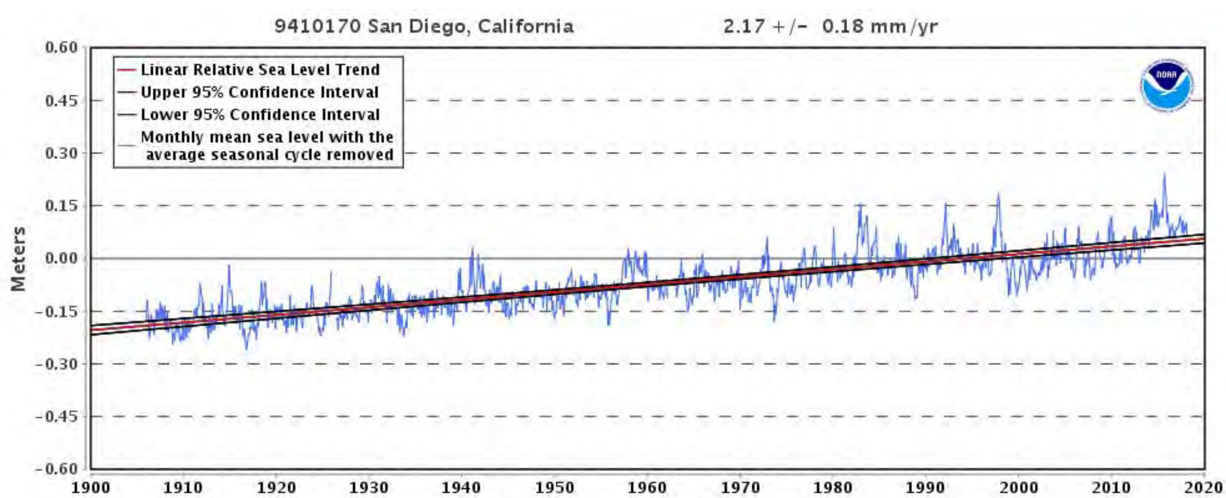

Figure 61. The relative sea level trend is 2.17 millimeters/year with a ninety-five percent confidence interval of +/- 0.18 mm/yr. based on monthly mean sea level data from 1906 to 2017, which is equivalent to a change of 0.71 feet in 100 years (tide gauge 9410170 San Diego, CA). Source: NOAA 2018.

Future Conditions: According to the recent California Coastal Commission Sea Level Rise Policy Guidance November 2018 update, sea levels in San Diego may rise by 0.6 to 1.1 feet by 2030, 1.2 to 2.8 feet by 2050, and 3.6 to 10.2 feet by 2100 (California Coastal Commission, 2018). Similarly, Kalansky et al. (2018) found that in San Diego County, sea level is projected to rise by approximately one foot by mid-century, and three feet or more by end-of-century. This range demonstrates the increasing uncertainty associated with estimating sea level rise in the long term, particularly in the latter half of the 21st century. The contribution of thermal expansion (i.e., ocean water volume expanding as ocean water warms), and small glaciers to sea level rise is relatively well-researched, while the impacts of climate change on large ice sheets are less understood. In general, the rise is projected to accelerate toward the second half of the century.

A variety of factors impact local relative sea level rise (i.e., the sea level rise projections for a specific location rather than the global average sea level rise projections), including vertical land movement, ocean dynamics, and changes in the Earth's gravitational and rotational fields (NRC, 2012). Through 2100, San Diego is projected to subside at a rate of 1.4 mm/year, and the glacial geostatic adjustment[53] is projected to cause local relative sea level to increase by 0.4 mm/year (NRC, 2012). These values are factored into San Diego region sea level rise projections.

ICF has integrated the sea level rise and storm surge scenarios from the CoSMoS sea level rise and storm surge modeling into an interactive online map that can be used to explore current and future flood risks. The primary CoSMoS layers included in the tool are provided in Table 77. The 1.5-meter CoSMoS scenario has been added to provide additional insight on the timing and phasing of future flooding. The mapping tool includes daily inundation, annual storm, and 100-year storm events for each of the sea level rise increments.

Table 77. Sea Level Rise Scenarios following California Coastal Commission Sea Level Rise Policy Guidance and Projections

Year	Low Risk Aversion Scenario 17% probability SLR meets or exceeds		Medium-High Risk Aversion 0.5% probability SLR meets or exceeds		Extreme Risk Aversion Scenario H++ scenario, no assigned probability	
	CCC 2018 Projection	Closest CoSMoS Increment	CCC 2018 Projection	Closest CoSMoS Increment	CCC 2018 Projection	Closest CoSMoS Increment
2030	0.6 ft.	0.25 m (0.8 ft.)	0.9	0.25 m (0.8 ft.)	1.1 ft.	0.25 m (0.8 ft.)
2050	1.2 ft.	0.25 m (0.8 ft.)	2.0 ft.	0.5 m (1.6 ft.)	2.8 ft.	0.75 m (2.5 ft.)
2100	3.6 ft.	1 m (3.3 ft.)	7.0 ft.	2 m (6.6 ft.)	10.2 ft.	2 m (6.6 ft.)

Extreme flood frequency is expected to increase under all projections of sea level rise. In addition, rising seas boost the occurrence of severe floods (such as the 500-year flood) more than moderate floods (such

[53] The Earth's crust is still reaching a state of equilibrium after the melting of the glaciers at the end of the last ice age. This process is called glacial geostatic adjustment. Some locations that were compressed due to the huge weight of the ice are still rebounding, while areas that were near, but not covered with glaciers were pushed up during the ice age and are still subsiding.

as the 10-year flood) along the Pacific coast of the United States (Buchanan, 2017). By elevating storm tide, sea level rise makes it easier for waves to surpass natural barriers, increasing the relative frequency of flooding along the Pacific coast.

Coastal Erosion

> Coastal erosion has long been an issue along Sunset Cliffs, La Jolla Cove, and Torrey Pines. In addition, the City regularly places new sand on beaches to maintain their width. With sea level rise and changes in storms, coastal erosion is expected to increase, though there is considerable uncertainty regarding where and when that may occur.

Past and Present Conditions: The relatively soft sandstone bluffs that are common along the San Diego coast are prone to erosion from waves and from storm water runoff. The last City-wide coastal erosion assessment, consisting of geotechnical reports, site visits, and photographic documentation of erosion, was completed in 2003 (City of San Diego, 2003). That study identified eleven high-priority sites with conditions that "present potential public hazards." These sites include:

1. Osprey Street to Adair Street (Spalding Park)
2. Hill Street to Guizot Street
3. Guizot Street to Froude Street
4. Froude Street to Osprey Street
5. Nautilus Street to Westbourne Street (Stairwell)
6. Diamond Street to Missouri Street
7. Coast Boulevard – split to Children's Beach (bluff top and sidewalk)
8. La Jolla Cove (North of 1325 Coast Blvd)
9. Mission Beach Park
10. Sun Gold Point to Cortez Place
11. Pt. Loma Ave to Bermuda Ave (Pt. Loma Ave street-end and storm drain)

Figure 62. Erosion assessment images for Hill Street to Guizot Street from 1993, 2003, and 2018. Source: ICF 2018.

In 2018, ICF delivered a high-level update the 2003 assessment (ICF, 2018). This update included re-visiting the sites from the 2003 assessment to take new photographs and documents visual changes in the level of erosion. The update indicates that while the City has made improvements to pedestrian access and safety along the erosion sites, more sites pose threats to pedestrians relative to 2003. For instance, currently, twenty-seven percent of the seventy-one sites identified pose pedestrian hazards, have limited pedestrian access because of erosion, and/or have signs of imminent bluff collapse, while just sixteen percent of sites showed these signs in 2003.

Future Conditions: Cliff erosion is likely to increase with sea level rise and heavier rainfall events, but modeling when and where can be difficult. New research by Scripps indicates that cliffs cycle through periods of erosion and stability, meaning that historical erosion rates are not always an accurate predictor of future erosion (Young, 2018). Areas that have been stable for some time may start eroding while areas that have been actively eroding may stabilize. Unfortunately, research has not yet determined how to predict in detail when cliff erosion may slow or accelerate.

Beach erosion is also likely to accelerate with sea level rise. While the City currently nourishes the beaches, it is likely that historical rates of nourishment would be insufficient to halt future beach erosion. A recent study (Vitousek, 2017) found that, although subject to considerable uncertainty, significant impacts to the shoreline would occur due to accelerated sea level rise, with 31 percent of beaches in Southern California lost by 2100 under the 0.93 meter (3 feet) sea level rise projections.

ICF integrated coastal erosion into the interactive online map tool. The layers include CoSMoS cliff erosion and shoreline change. Given the complexity and uncertainty of modeling coastal erosion, ICF plans to supplement the CoSMoS erosion modeling with the institutional knowledge of City departments through discussions on coastal erosion vulnerabilities.

Salt Water Intrusion

As groundwater resources are affected by changes in precipitation, drought events, and withdrawal rates, and as sea levels rise, salt water can seep into underground aquifers; however, determining when and where this may occur is still being researched by the scientific community.

Past and Present Conditions: A supplemental consideration for coastal hazards is the threat posed by salt water intrusion. In San Diego County, groundwater levels have declined, leading to salt water intrusion over time (Wen, 2014).

Future Conditions: Research indicates that further salt water intrusion could occur with rising sea levels (San Diego Foundation, 2012). In particular, the San Diego Formation aquifer may experience salt water intrusion from San Diego Bay depending on the extent of future groundwater pumping, precipitation, presence of channels, storm events, and sea level rise. The amount of future salt water intrusion and the exact areas cannot be determined at this time.

Precipitation

The primary concerns for precipitation-driven hazards are historical flood areas and changes in annual and extreme precipitation. Supplemental considerations include changes in drought and landslides.

Annual Average Precipitation and Extreme Precipitation

Precipitation is one of the more difficult variables for climate change models to project. For the San Diego region, the models only show a slight change in average annual rainfall, but overall there is expected to be more variability in rainfall from year to year and more intense transitions between droughts and deluges.

Past and Present Conditions: California can experience wide swings in precipitation from drought years to El Niño years. From 1939 to 2016, the average annual rainfall at San Diego Airport was 10.13 inches (Western Regional Climate Center, 2018).

Future Conditions: Annual average precipitation values from Cal-Adapt and other sources project only modest changes (Seager, 2015). While historical annual average precipitation was ten inches, approximately nine to ten inches are expected by mid- and late century, under both low and high emissions scenarios. These projections are based on the ensemble average of four recommended climate models for the area (MIROC5, HadGEM2-ES, CNRM-CM5, CanESM2).

Projections for total annual precipitation in the State of California have not reached a firm consensus; some simulations indicate that the region would become drier while others indicate that it would become wetter (Messner, 2009). For example, a study accounting for possible warm wet winters associated with El Niño conditions, projects a twelve percent increase in precipitation in California from 2020 to 2100, compared with 2000 to 2017 (Allen, 2017). Another recent study projects that there would be both more extreme wet years *and* more extreme dry years, as shown in the top and middle graphs of Figure 63 (Swain, 2018). Specifically, 1-in-25 year wet extremes (similar to the 2016 to 2017 wet season) and 1-in-100 year dry extremes (slightly drier than 2013 to 2014) are expected to become 2.5 times more frequent by the end of the century, relative to 1985 to 2017 (Swain, 2018). Overall there is expected to be more variability in precipitation and more intense transitions between the two, as occurred in 2015 to 2016 and 2016 to 2017 when an extremely dry year was followed by an extremely wet year, as shown in the bottom graph of Figure 63 (Swain, 2018).

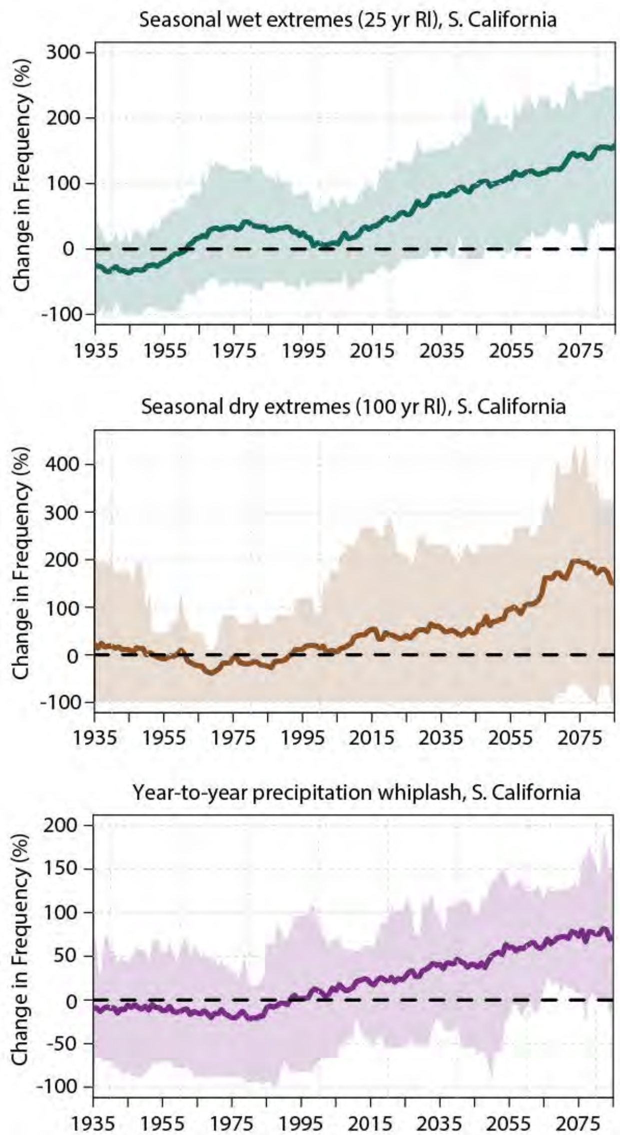

Figure 63. Relative change [percent] in extremely wet seasons (top), extremely dry seasons (middle), and year-to-year whiplash (bottom) by end of century in Southern California. Source: Swain et al. 2018.

The City of San Diego will likely continue to be vulnerable to extreme precipitation events and drought. One study estimated that while San Diego would see fewer rainy days by 2050, the biggest rainstorms would be bigger than they are now in terms of rainfall (Higbee, 2014). Extreme precipitation events (that historically occurred every twenty-five years, on average) are expected to become 2.5 times more frequent in Southern California (Swain, 2018). That implies that what would be considered extreme in the future will be even stronger than what we experience as extreme now.

Precipitation-Driven Flood Areas

Areas of San Diego (e.g., Mission Valley) already flood when there are heavy rainfall events. As rainfall events get stronger in the future, the area affected by inland flooding would increase.

Past and Present Conditions: Historically, FEMA has prepared 100-year and 500-year flood channel maps to indicate potential areas of inland flooding during heavy rainfall events, based on past conditions. These FEMA maps have been incorporated into the online mapping tool that ICF is creating for the City of San Diego. Although there are some known shortcomings to these maps—primarily that they are based solely on historical climate and do not yet incorporate projected changes in climate—they are the best information that is comprehensively available for the City.

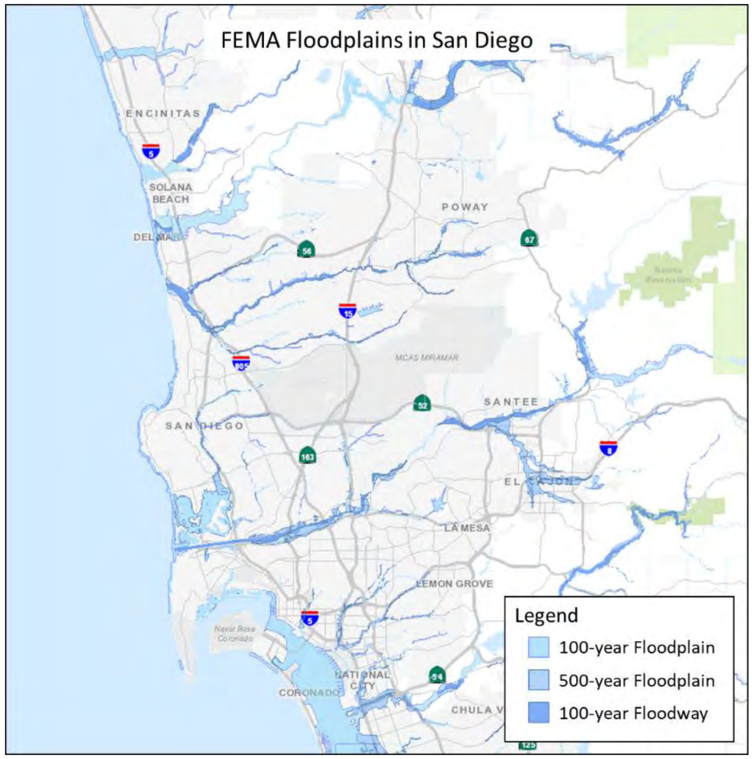

Figure 64. FEMA floodplains in San Diego. Source: [SANDAG SanGIS.]

Inland flooding is also impacted by the ability of storm water to drain. Increases in sea level rise may inhibit gravity-fed drainage systems if the water cannot escape through the outfalls.

Future Conditions: With heavier rainfall events would come expanded and new areas of inland flooding. Mapping of potential changes in the frequency and extent of inland flooding events in the region is not available currently.

Droughts

Drought has ravaged California in recent years and the future doesn't look much better. While droughts will always be cyclical, droughts are projected to become more frequent and drier.

Past and Present Conditions: California has recently emerged from one of the worst droughts in its history. It is thought that climate change has already begun to increase the occurrence of warm-dry conditions that result in drought (Diffenbaugh, 2015).

Future Conditions: While projections of precipitation indicate high inter-annual variability, droughts themselves are projected to be drier (by twenty percent) and occur more frequently in San Diego by the early twenty-first century (Messner, 2009). Swain et al. (2018) expect that extremely dry years (that historically occurred once every

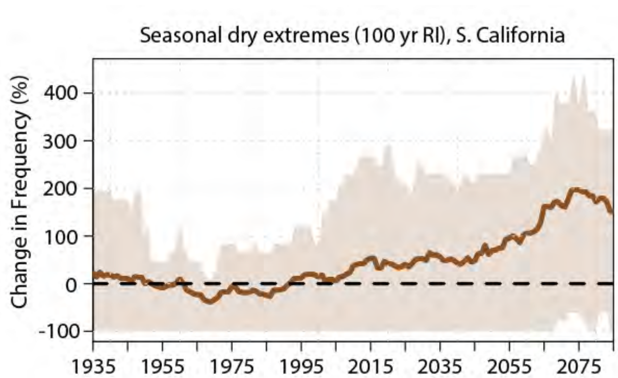

Figure 65. Relative change [percent] in extremely dry seasons. Source: Swain et al. 2018.

100 years, on average) would become 2.4 times as frequent in Southern California after 2050, relative to the pre-industrial era, as shown in Figure 65. Extended droughts, or "mega-droughts" are also projected to become more pervasive in the future. Figure 66, below, shows projections for maximum temperature and average annual rainfall under a twenty-year mega-drought drought scenario.

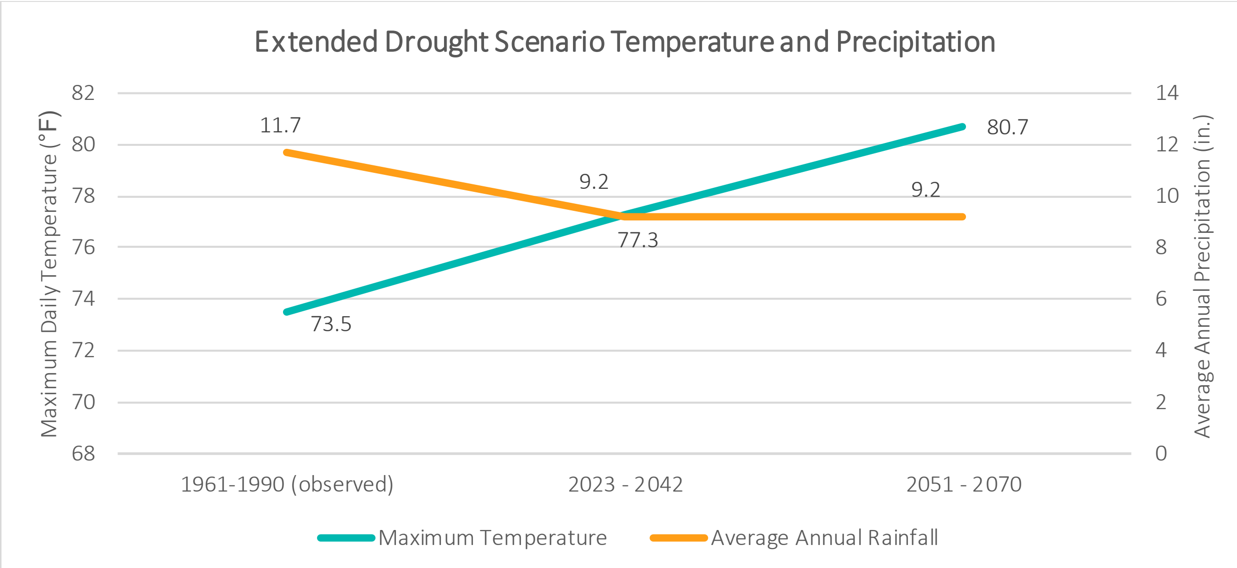

Figure 66. Extended drought scenario simulation of maximum daily temperatures and average annual precipitation, from the HadGEM2-ES climate model, emissions scenario RCP 8.5. Time periods are based on twenty-year water year (i.e., Oct to Sep) averages. Source: Cal-Adapt 2018.

Landslides

With changing wildfire and precipitation patterns, the risk of mudslides and landslides may be increasing in San Diego.

Past and Present Conditions: The County of San Diego analyzed landslide risks in the 2010 Multi-Jurisdictional Hazard Mitigation Plan (San Diego County, 2010). The map of high-risk areas can be viewed here.

Future Conditions: The threat of landslides, including mudslides, is also projected to change under climate change. Extreme precipitation is one of the main causes of slope instabilities. As such, climate change-induced increases in extreme precipitation events have the potential to decrease slope stability and increase the frequency of landslides (Robinson, 2016). Additionally, the risk of rain-induced landslides is significantly higher following a wildfire. The section below discusses wildfire risks. Mapping of potential changes in the frequency and extent of landslide and mudslide events is not available currently.

Temperature

To evaluate the threat of temperature changes, ICF assessed projections for extreme temperature and expanding summer season, cooling and heating degree days, heat waves, and urban heat island.

Daily Temperatures

Extreme Heat Days

San Diego is known for its pleasant temperatures—in the past, extreme highs (93 degrees Fahrenheit) have only occurred about four days a year. However, those pleasant temperatures are projected to change. By the 2080's, each year could include up to a month with daily highs over 93 degrees Fahrenheit.

Past and Present Conditions: San Diego routinely experiences hot summer days. "Extreme heat" for the City of San Diego is defined as a day with a maximum temperature exceeding 93.1 degrees Fahrenheit.[54] Historically (1960 to 1990), there have been four extreme heat days per year in the City of San Diego.

Future Conditions: Climate projections indicate that San Diego will experience more frequent extreme heat days. ICF used Cal-Adapt to investigate the average annual extreme heat days for mid-century and end-of-century time periods under both low and high emissions scenarios (Figure 67).[55] By mid-century (2035 to 2064), extreme heat days could increase to eleven days under a low emissions scenario and fifteen days under a high emissions scenario. By the late century (2070 to 2099), this could further increase to sixteen days under the low emission scenario and thirty-two days under the high emission scenario.

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[54] More specifically, an extreme heat day is defined as a day in April through October when the maximum temperature exceeds the City of San Diego's ninety-eighth percentile of historical maximum temperatures between April 1 and October 31 based on observed daily temperature data from 1961 to 1990. This threshold for extreme heat days is calculated to be 93.1 degrees Fahrenheit. In other words, historically, this temperature was only exceeded in the City of San Diego two percent of all days.

[55] Four climate models were used for this analysis (HadGEM2-ES, CNRM-CM5, CanESM2, and MIROC5), all of which have been selected by California state agencies as priority models for research contributing to California's Fourth Climate Change Assessment.

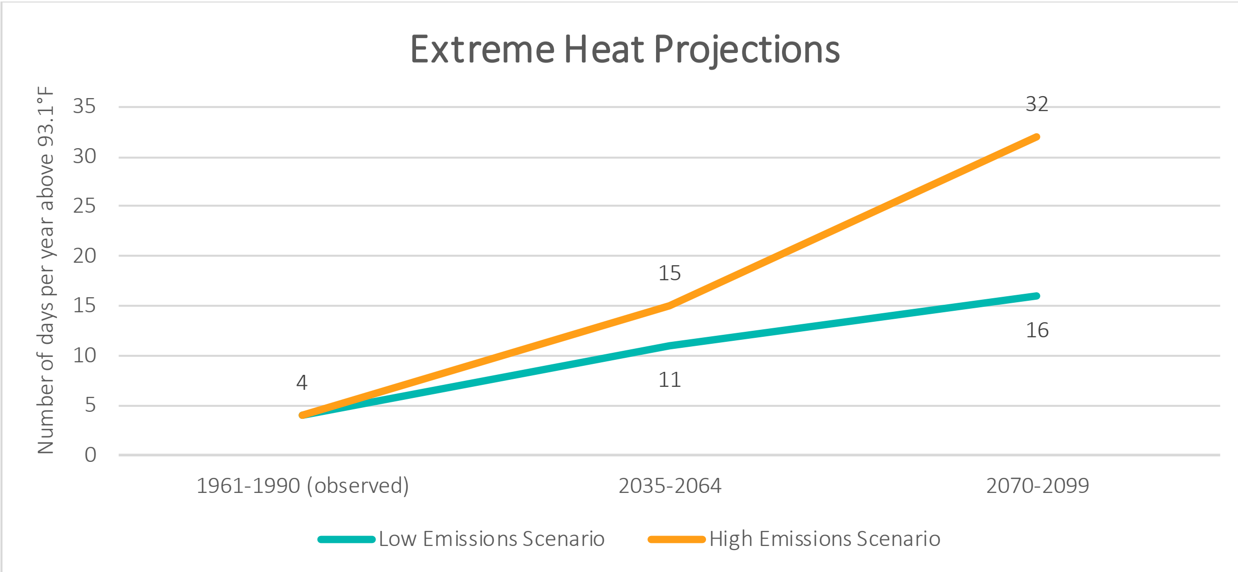

Figure 67. Extreme heat projections for San Diego throughout this century under low and high emission scenarios. Source: Cal-Adapt 2018.

Average Daily Maximum Temperatures

It's not only the hottest days that are going to get hotter — average winter, spring, summer, and fall temperatures will be hotter than they used to be. In the 2040s, the daily high could be 5 degrees Fahrenheit higher throughout the year, and in the 2080s it could be up to 8 degrees Fahrenheit higher.

Past and Present Conditions: Another way of considering increasing extreme temperatures is the gradual increase in the annual average maximum temperature. Historically (1961 to 1990), the annual average daily maximum temperature for San Diego was 73.6 degrees Fahrenheit.

Future Conditions: Using Cal-Adapt and the same climate models and timeframes as for extreme heat days, ICF concluded that by the end of the century, under a high emissions scenario, daily maximum temperatures could be almost 8 degrees Fahrenheit warmer than they are today (Figure 68). By mid-century (2035 to 2064), daily maximum temperatures are projected to increase to 77.2 degrees Fahrenheit under a low emissions scenario and to 78.1 degrees Fahrenheit under a high emissions scenario. By the late century (2070 to 2099), these temperatures are projected to reach 78.5 degrees Fahrenheit under the low emission scenario and 81.3 degrees Fahrenheit under the high emission scenario.

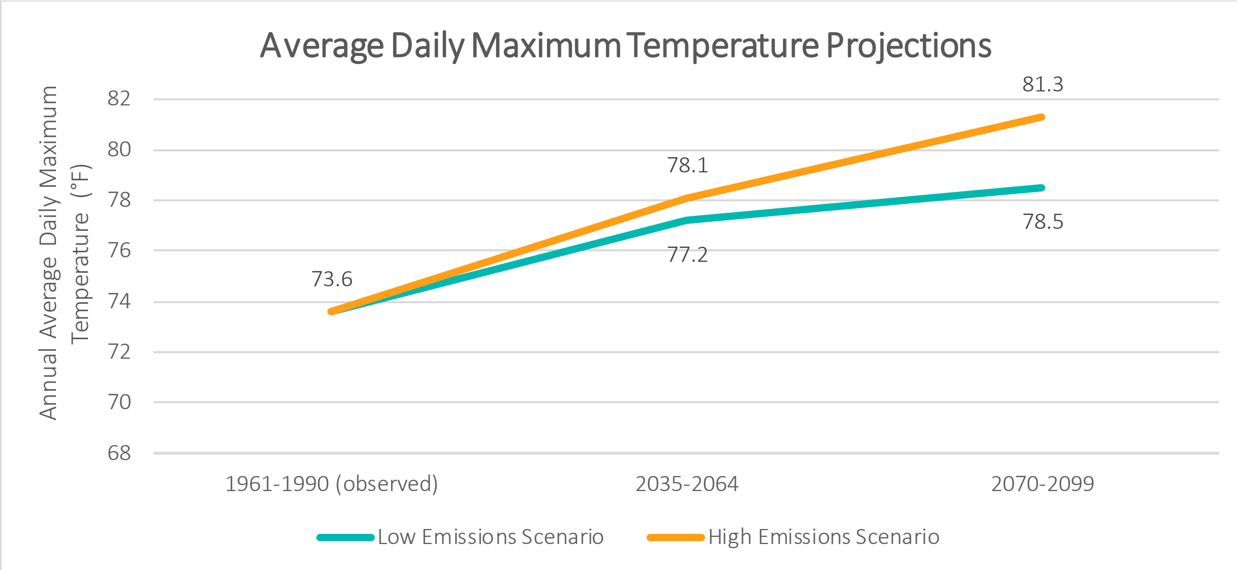

Figure 68. Average daily maximum temperature projections for San Diego throughout this century under low and high emission scenarios. Source: Cal-Adapt 2018.

Expanding Summer Season

June gloom may become a thing of the past as hot summer days shift from starting in August to kicking off the summer season as early as June.

Past and Present Conditions: Historically, San Diego's summer season has started later than other parts of the United States. Most extreme heat days occurred in August to October (Cal-Adapt, 2018).

Future Conditions: According to climate change projections, in addition to more hot days, those days are expected to occur over a wider range of months, effectively lengthening the summer season. Figure demonstrates that in the future, extreme heat days may be experienced much more often as early as June. The blue boxes in Figure show that increase: extreme heat days in the 1960s and 1970s were concentrated in September and October, while extreme heat days from the 2070s onward occur frequently from June through October.

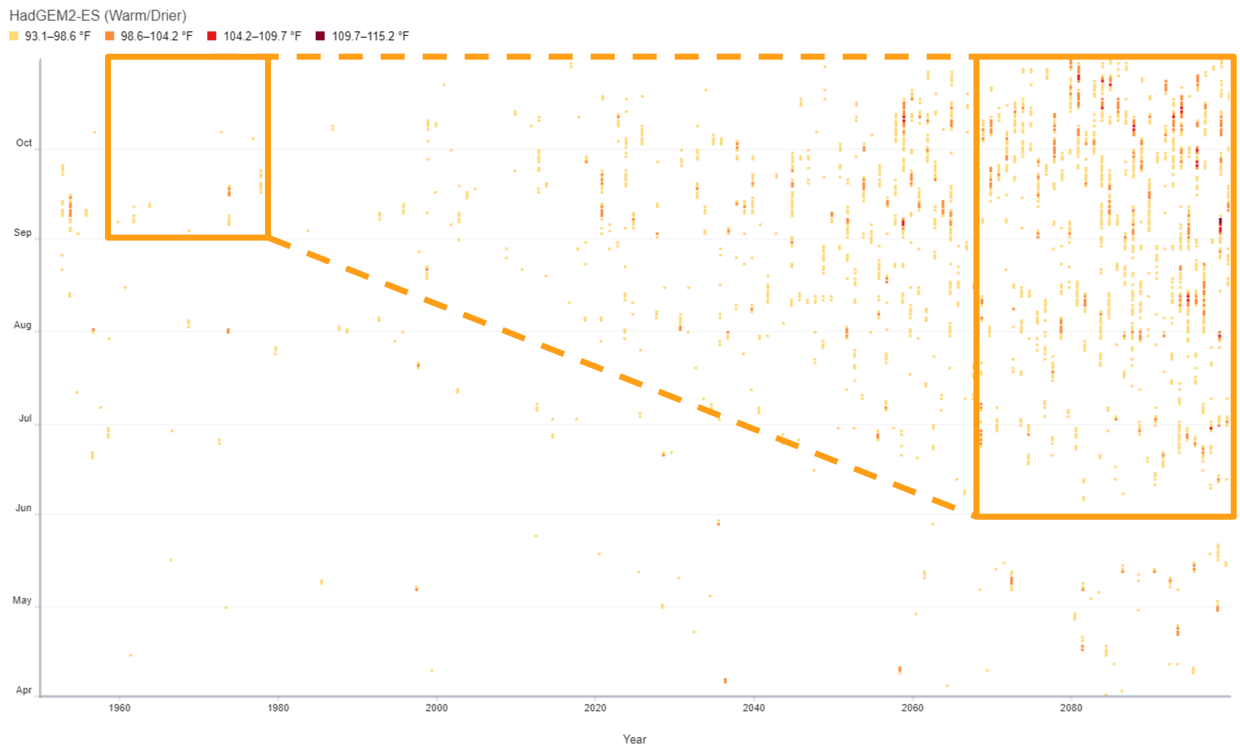

Figure 69. Timing of Extreme Heat Days (RCP 8.5, HadGEM2-ES model). Source: Cal-Adapt 2018.

Cooling Degree Days and Heating Degree Days

Even today, more and more residents and businesses are installing air conditioners. By the end of the century, demand for air conditioning could double or triple over historical levels. On the other hand, demand for winter heating could become almost non-existent by the end of the century.

Past and Present Conditions: Cooling degree days and heating degree days are used by utilities and other planning entities as an indicator of forecasted demand for energy to run air conditioning and heaters. For the purposes of analysis, Cal-Adapt uses the following approach to calculate cooling degree days:

> "A Cooling Degree Day (CDD) is defined as the number of degrees by which a daily average temperature exceeds a reference temperature. The reference temperature is typically 65 degrees Fahrenheit, although different utilities and planning entities sometimes use different reference temperatures. The reference temperature loosely represents an average daily temperature below which space cooling (e.g., air conditioning) is not needed. The average temperature is represented by the average of the maximum and minimum daily temperature."

For example, a day with an average temperature (i.e., not the maximum temperature, but the average throughout the day) of 72 degrees Fahrenheit would be counted as 72°F–65°F = 7 CDDs.

CDDs serve as a proxy for energy demand, since the reference temperature represents the temperature at which space cooling, such as air conditioning, is turned off. When average temperatures climb above this reference temperature, space cooling is turned on, and is used more frequently and intensely as the temperature gets hotter. Historically, there are roughly 1,000 CDDs in a year for San Diego.

Heating degree days are calculated in the same fashion but using a different reference temperature and summing days with an average temperature that falls below the threshold temperature. Historically, there are roughly 1,300 heating degree days in a year.

Future Conditions: Figure shows that the energy demand for cooling could double or triple current levels by the end of the century under low and high emission scenarios, respectively.

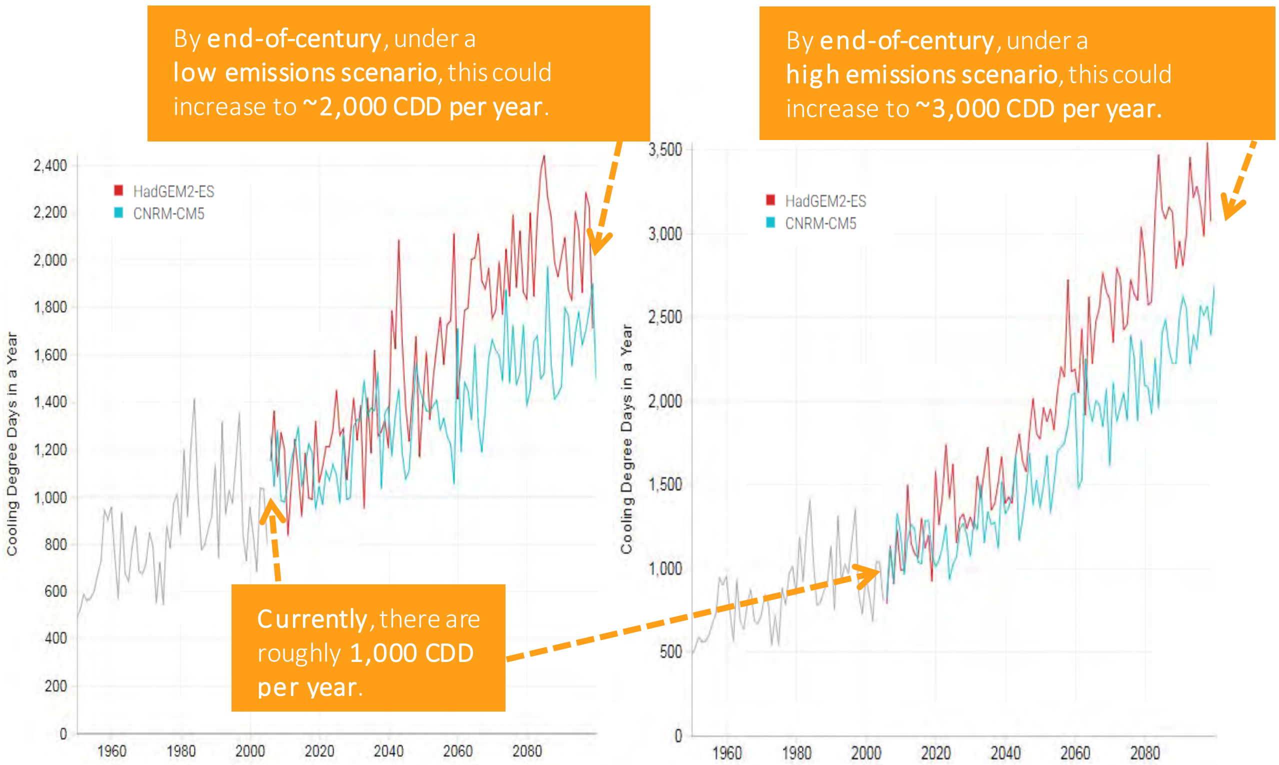

Figure 70. Left: Historical and projected Cooling Degree Days (CDD) under RCP4.5 and two climate models. Right: Historical and projected CDD under RCP 8.5 and two climate models. Source: Cal-Adapt 2018.

While CDDs are projected to increase, heating degree days are projected to decrease over time as the winters become warmer, thus decreasing the need for heating (see Figure 71) (Cal-Adapt, 2018). Historically, there are roughly 1,300 heating degree days per year. By the end of the century, San Diego could be experiencing as few as 500 to 100 heating degree days per year (under a low emission and high emission scenario, respectively). This means there will be less need for heating during colder months.

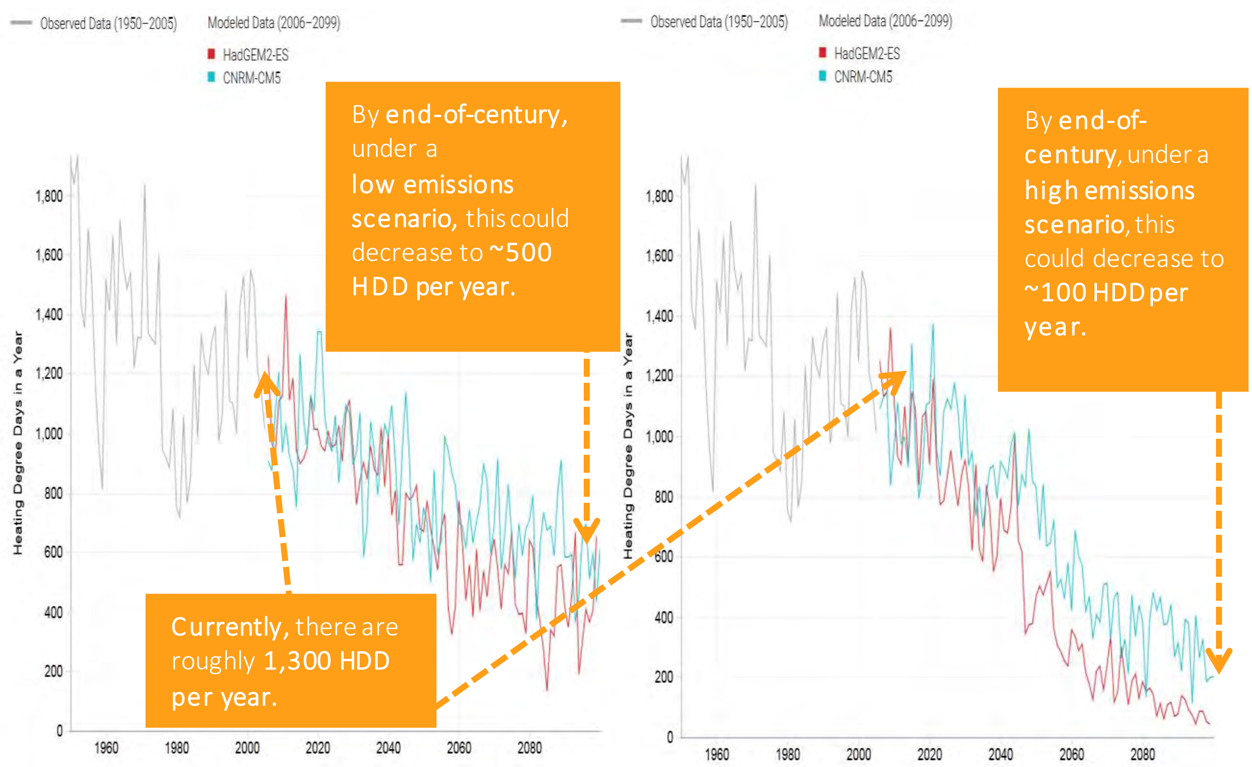

Figure 71. Left: Historical and projected Heating Degree Days (HDD) under RCP 4.5 and two climate models. Right: Historical and projected HDD under RCP 8.5 and two climate models. Source: Cal-Adapt, 2018.

Heat Waves

Everyone knows that heat waves aren't nearly as fun as riding the surf. By mid-century, heat waves could be occurring three to five times more frequently than historically and each heat wave could drag out for over twice as many days.

Past and Present Conditions: San Diego has not been prone to heat waves in the past. Historically (1960 to 1990), there has been one four-day heat wave[56] approximately every other year, and an average maximum of 2.5 consecutive extreme heat days per year in the City of San Diego.

Future Conditions: ICF surveyed recent literature and found that similar to extreme heat, heat waves are projected to increase in frequency, magnitude, and duration (Messner, 2009). Recently released California Fourth Climate Assessment data also show that heat wave frequency is projected to increase (Kalansky, Cayan, Barba, Brouwer, & Boudreau, 2018). San Diego is projected to experience 0.6 to 1.4 more four-day heat waves per year by mid-century, and 1.2 to 4.2 more heat waves per year by late

[56] Heat waves are defined as 4-day events where daily maximum temperatures exceed 93.1 degrees Fahrenheit.

century, as shown in Figure 72, below. These frequencies are averages over thirty years, which explains why they are not whole numbers.

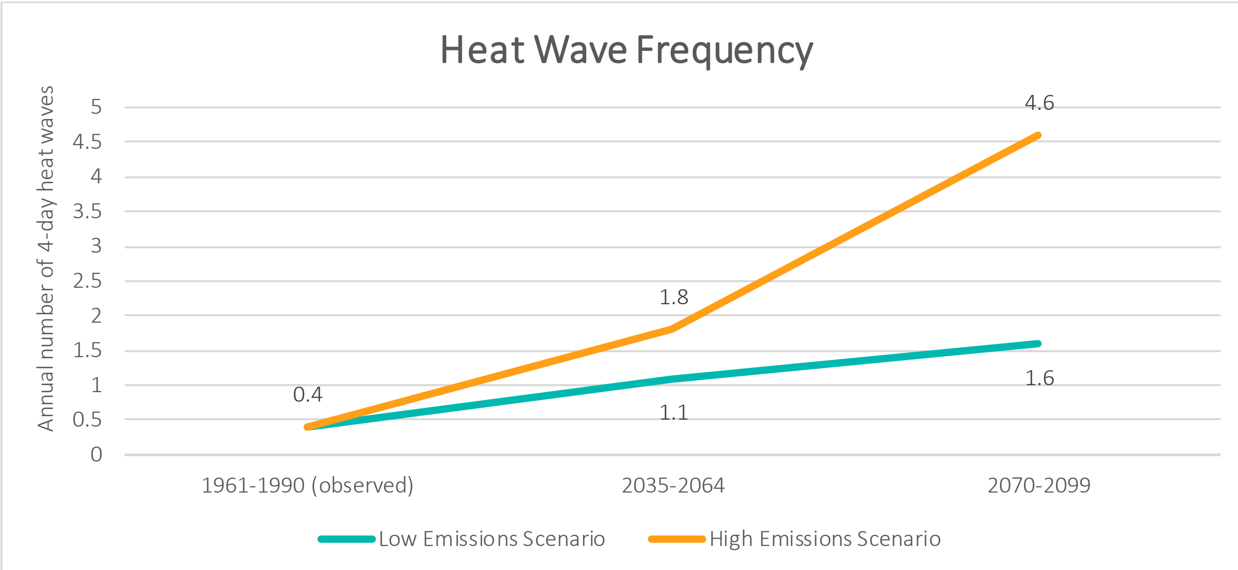

Figure 72. Four-day heat wave frequency projections for San Diego throughout this century under low and high emission scenarios. Source: Cal-Adapt 2018.

Similarly, the longest stretch of consecutive extreme heat days is projected to increase, as shown below in Figure 73. By mid-century, the longest stretch of consecutive extreme heat days is projected to last nearly five days under a low emissions scenario, and nearly six days under a high emissions scenario. By late century, this period is projected to span over five days under a low emissions scenario, and over a week under a high emissions scenario.

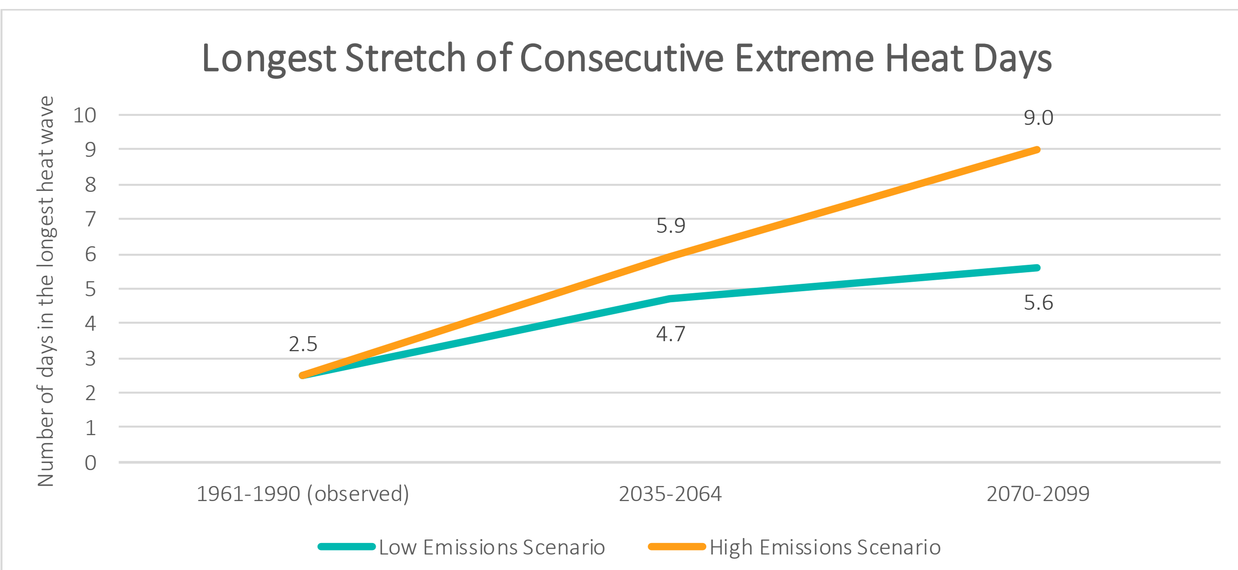

Figure 73. Projections for longest stretch of consecutive extreme heat days for San Diego throughout this century under low and high emission scenarios. Source: Cal-Adapt 2018.

Minimum Temperatures and Warm Nights

Warm Nights

Warm nights pose a health risk as they limit nighttime cooling and physiological recovery during heat waves and prolong the period over which heat-driven negative health outcomes can take place (Steinberg, 2018). The frequency and duration of warm nights is projected to increase substantially by mid- and late century within San Diego.

Past and Present Conditions: Daily minimum temperatures, which generally represent the nighttime low temperature, are important for allowing people and infrastructure to cool off before the start of another day. Historically (1961 to 1990), the annual average daily minimum temperature for San Diego was 52.9 degrees Fahrenheit.

By definition, warm nights in San Diego occur when the daily minimum temperature exceeds the minimum temperature heat threshold of 67.9 degrees Fahrenheit.[57] Historically (1960 to 1990), there have been four warm nights per year in the City of San Diego, which have generally been concentrated in August and September.

Future Conditions: While the daily maximum temperatures are projected to increase, so are the daily minimum temperatures, resulting in warmer nights (see Figure 74). Using Cal-Adapt and the same climate models and timeframes as for extreme heat days and average daily maximum temperatures, ICF concluded that by the end of the century, under a high emission scenario, daily minimum temperatures could be 8 degrees Fahrenheit warmer than they are today.

[57] 67.9 degrees Fahrenheit is the ninety-eighth percentile historical minimum temperature threshold.

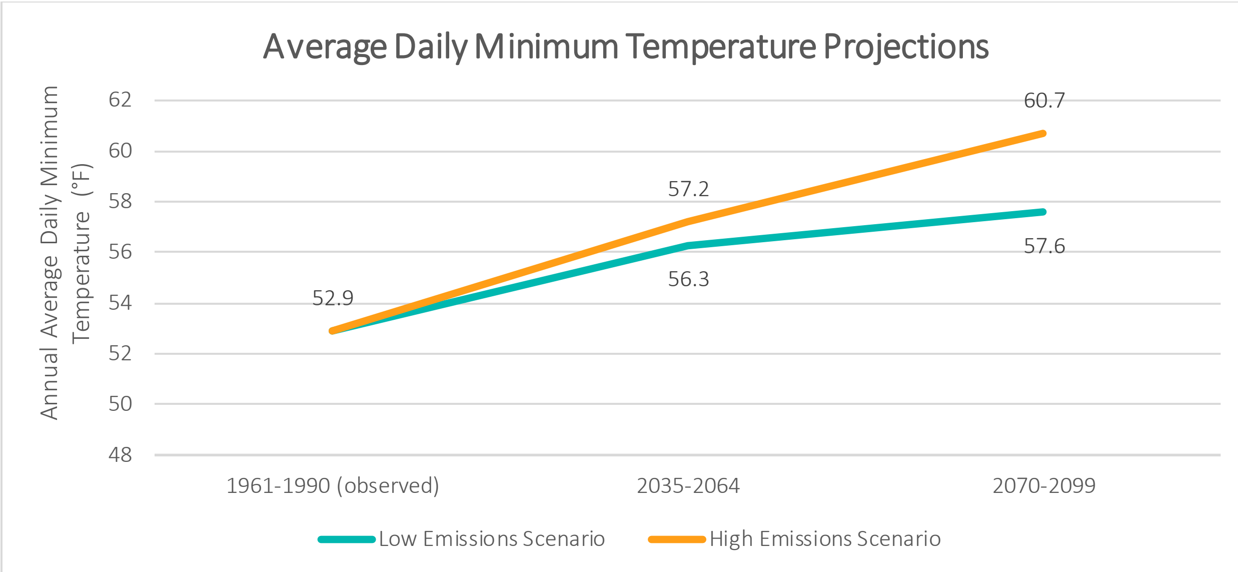

Figure 74. Average daily maximum temperature projections for San Diego throughout this century under low and high emissions scenarios. Source: Cal-Adapt 2018.

The annual number of warm nights is projected to increase substantially throughout the century, as shown in Figure 75, below. By mid-century, San Diego is projected to experience between three weeks and slightly over one month of warm nights per year. By late century, the City is projected to experience between a month and over three and a half months of warm nights per year.

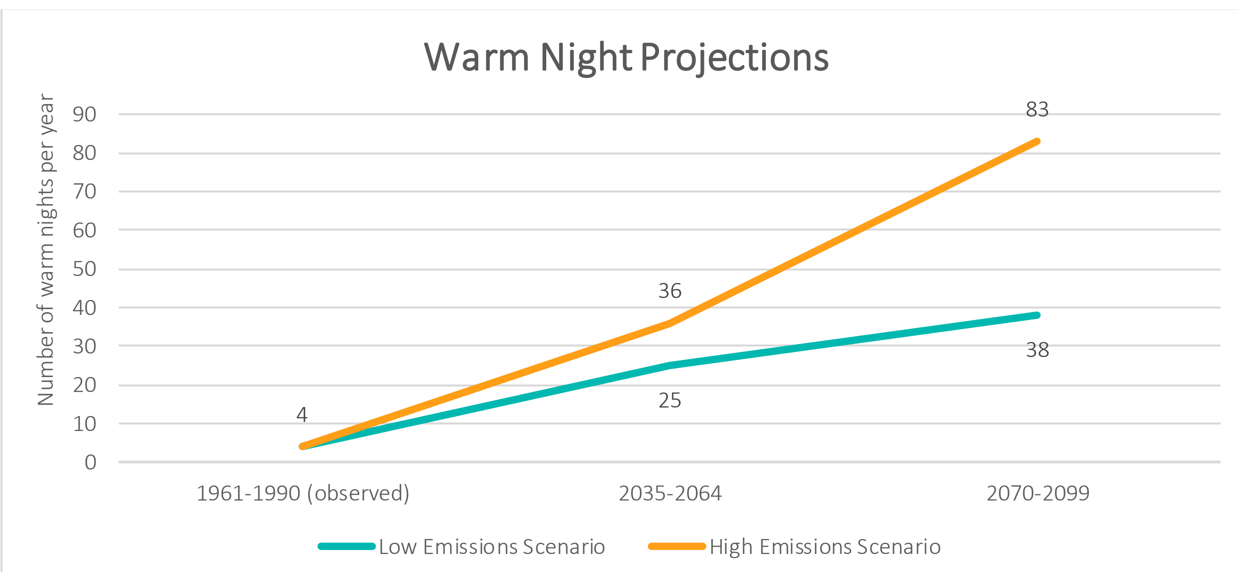

Figure 75. Projections for annual number of warm nights for San Diego throughout this century under low and high emissions scenarios. Source: Cal-Adapt 2018.

Warm nights are also expected to occur over a wider range of months, lengthening the season of warm nights. The blue boxes in Figure 76 show that lengthening: extreme heat days in the 1960s and 1970s are concentrated in August and September, while extreme heat days from the 2070s onward occur frequently from June through October.

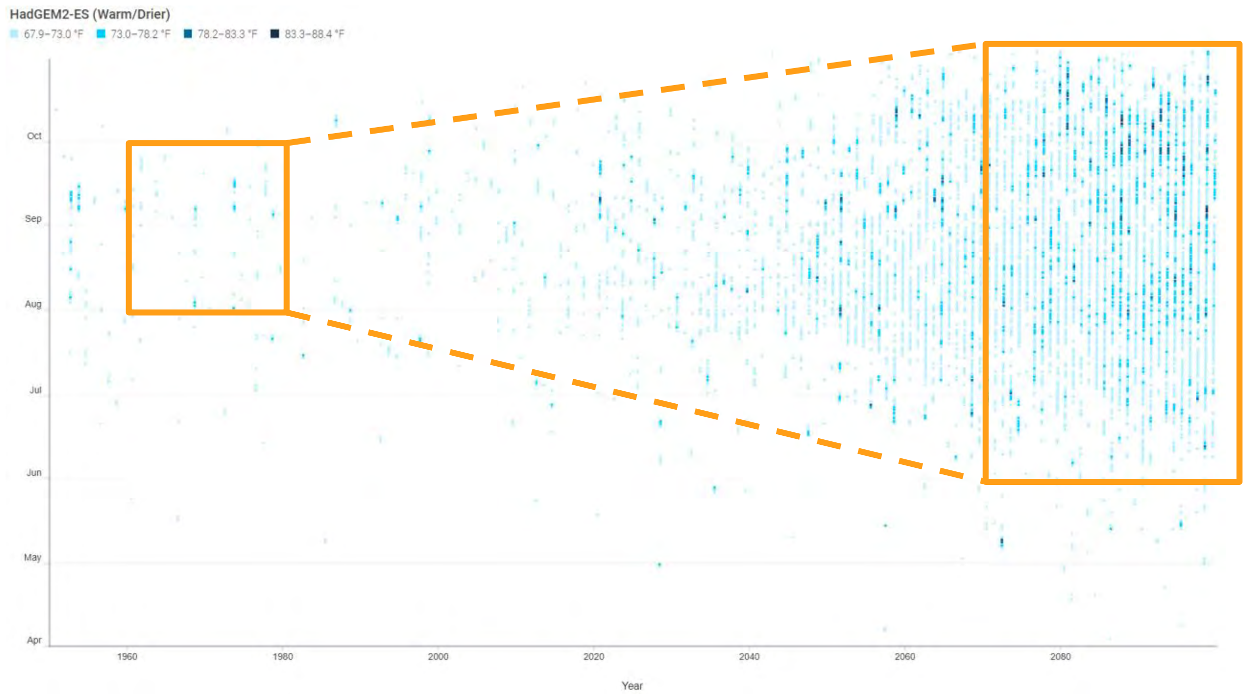

Figure 76. Timing of warm nights (RCP 8.5, HadGEM2-ES model). Source: Cal-Adapt 2018.

Night Heat Wave

Consecutive hot days and warm nights pose even greater human health risks. San Diego could be moving from very infrequent nighttime heat waves (about every other year) to up to six per year by mid-century, with the longest night heat wave extending stretching to almost two weeks.

Past and Present Conditions: On average, the City has experienced about one nighttime heat wave[58] every other year. The longest stretch of consecutive warm nights has historically lasted an average of 2.3 days.

Future Conditions: Nighttime heat waves are also projected to occur more frequently. San Diego is projected to experience three to five more nighttime heat waves per year by mid-century, and five to sixteen more nighttime heat waves per year by late century, as shown in Figure 77, below.

[58] Heat waves are defined as four-day events where daily minimum temperatures exceed 67.9 degrees Fahrenheit.

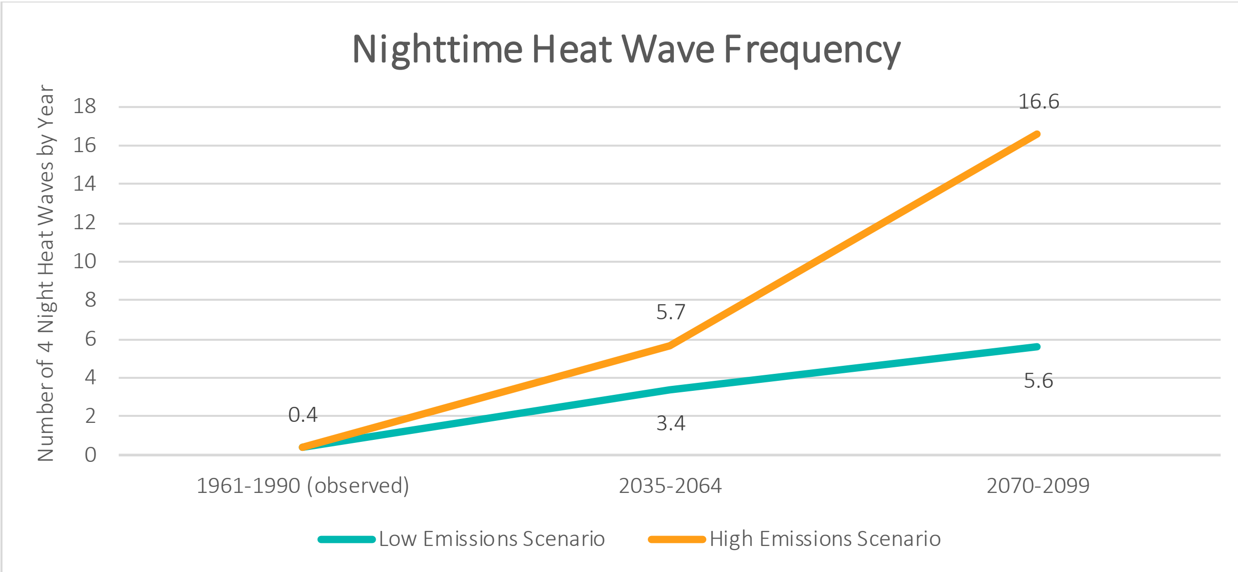

Figure 77. Nighttime heat wave frequency projections for San Diego throughout this century under low and high emission scenarios. Source: Cal-Adapt 2018.

Similarly, the longest stretch of consecutive warm nights is projected to increase, as shown in Figure 78, below. By mid-century, the longest stretch of consecutive warm nights is projected to span over a week under a low emissions scenario, and nearly two weeks under a high emissions scenario. By late century, this period is projected to last for a week and a half under a low emissions scenario, and five and a half weeks under a high emissions scenario.

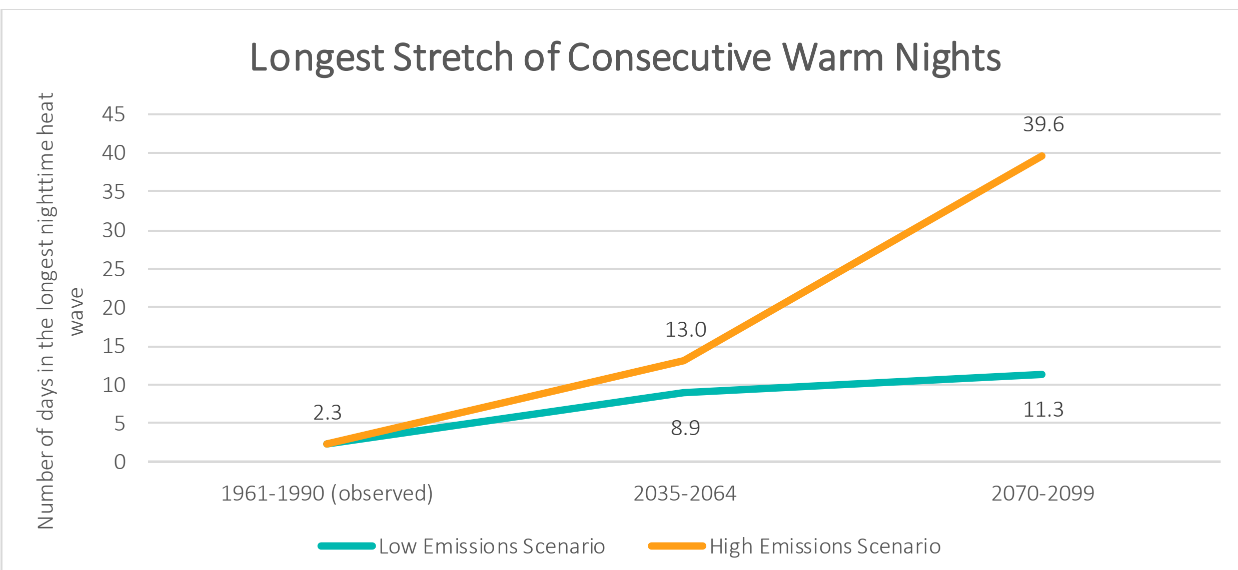

Figure 78. Projections for longest stretch of consecutive warm nights for San Diego throughout this century under low and high emission scenarios. Source: Cal-Adapt 2018.

Urban Heat Island

In San Diego, temperature gradients across the City are more dependent on the natural form of the City (i.e., cool coastal breezes lower the temperature close to the coast while inland temperatures remain hot) than on the built environment. While portions of downtown may be hotter because of the pavement and buildings than they would otherwise be, the natural landscape helps to keep them reasonably cool.

Past and Present Conditions: The built environment can influence temperatures on a micro scale. Dense urban environments with limited tree coverage and significant levels of pavement can increase temperatures above those experienced in more rural and natural areas, while coastal areas can benefit from ocean breezes to counteract these impacts. CalEPA has created an urban heat island map for San Diego. The urban heat islands are color coded according to their intensity, with green representing the smallest effect and red to white representing the greatest intensity. This information has been integrated into the online hazard map that ICF is developing.

This map generally shows what one would expect: it is hotter inland and cooler close to the coast. Unfortunately, it's difficult to determine from this map if the built form of San Diego is altering the temperature pattern in portions of the City. A recent study did find that urbanization in the Los Angeles and San Diego metropolitan areas has led to higher urban daytime air temperatures (Vahmani, 2016).

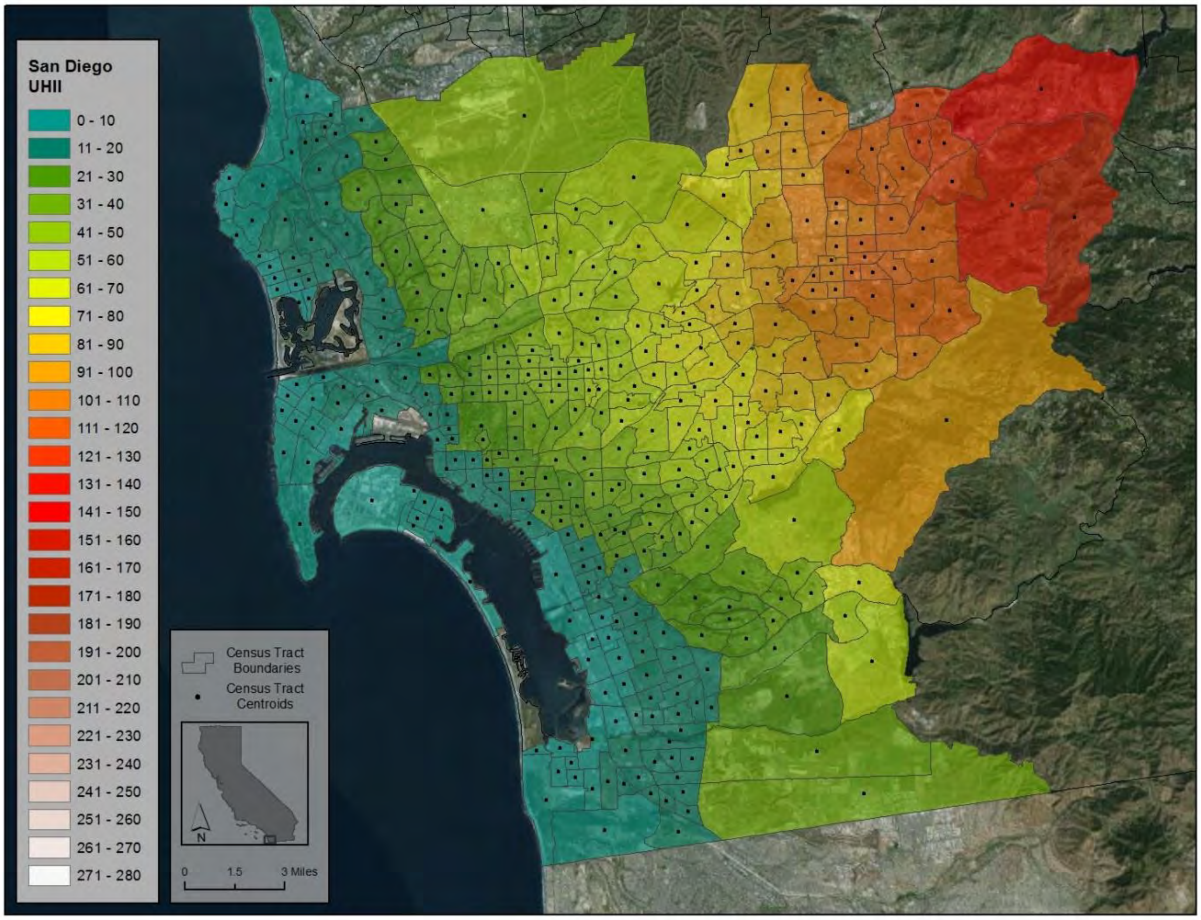

Figure 79. CalEPA Urban Heat Island Map. Source: CalEPA 2015.

Future Conditions: Future projections of urban heat island effects are difficult to produce since it is unclear how the built form will change over time. The City of San Diego vulnerability analysis will rely on the current understanding of urban heat island effects throughout the City.

Wildfires

Climate change will likely increase all the key drivers of wildfires – high temperatures, dry conditions, and flammable vegetation. While there is uncertainty in wildfire modeling, San Diego should anticipate wildfire risk to be of equal or greater severity than in recent decades.

Past and Present Conditions: Wildfires are driven by high ambient and extreme temperature, dry conditions, and the availability of fuel (e.g., vegetation). Historically, wildfires have been found to be larger and more severe in areas with intensive drought stress (Crockett and Westerling 2018). These wildfires were also followed by more tree mortality, increasing exposure to future wildfire.

Future Conditions: Climate change is projected to increase the drivers of wildfires and lead to an increase in fire risk (Yoon, 2015). The southwestern United States, including California, is expected to experience increased drought under climate change (Prein, 2016). Tree die-off in California has reached historic highs in recent years due to pine beetles, heat, and drought, which are expected to increase under climate change, providing more fuel for fires (US Forest Service, 2016). Increases in drivers of wildfires under climate change mean that wildfires would occur more frequently (Westerling, 2006) during a longer wildfire season (Chmura, 2011) and burn longer and more intensely (Westerling, 2006; Liu, 2010). In the San Diego region, wildfire risk is projected to increase, as is the risk of large catastrophic wildfires that arise from the Santa Ana winds (Kalansky, Cayan, Barba, Brouwer, & Boudreau, 2018). However, changes in wildfire risks within the City limits are less certain due to uncertainties around urban development and resulting fuel characteristics.

To assess the potential change in the occurrence of wildfire, the study team drew upon information supporting the Fourth California Climate Change Assessment. This includes a statistical model based on historical data of temperature, precipitation, vegetation, population density, fire occurrences, as well as downscaled projections of future temperature and precipitation by the mid- and late century. The ensemble average of four recommended climate models for the area (MIROC5, HadGEM2-ES, CNRM-CM5, CanESM2) were employed. Historically, an average of 657 hectares of land was burned annually across the City of San Diego. According to Cal-Adapt, an average of 311 to 319 hectares are expected to be burned annually by mid-century, under both the low and high greenhouse gas emission scenarios and a central population growth scenario. Under the same scenarios, an average of 291 to 301 hectares are expected to be burned annually by late century. These Cal-Adapt findings run counter to other studies which indicate an increase in wildfire hazard in future decades. This discrepancy may be due to the Cal-Adapt modeling approach, which assumes that an increase in urban infill reduces vegetation cover, reducing fire fuel availability. As a result, Cal-Adapt suggests a reduction in wildfire areas burned in urbanized areas of San Diego but suggests an increase in the less urbanized areas. Due to the uncertainty in the Cal-Adapt wildfire projections, and uncertainty surrounding changes in wildfire drivers such as fuel availability, fuel moisture, and the Santa Ana winds, it would be prudent for the City of San Diego to plan for a wildfire risk of equal or greater severity than that of recent decades.

Wildfires followed by heavy precipitation events could result in severe flooding and mudslides or landslides, such as those experienced in Southern California during the winter of 2017/18 (Bai, 2018).

Biodiversity

San Diego is proud to be a biodiversity hotspot, with hundreds of plant and animal species calling this area their home. However, climate change may shift habitat ranges around due to the climate factors discussed above. Some species will be able to keep up; others will not.

Past and Present Conditions: San Diego County is the most biodiverse county in North America and is part of the larger global biodiversity hotspot known as the California Floristic (San Diego State University Foundation, 2005; California Academy of Sciences, 2005). San Diego County harbors a great number of plant and animal species, many of which are endemic — meaning they are native to the area and not found anywhere else in the world. However, habitat destruction, pollution, and other factors are putting pressure on these important plants and animals. Approximately 200 of San Diego's species are threatened or endangered (The Nature Conservancy, n.d.)

Future Conditions: Changes in coastal hazards, temperature, precipitation, and wildfires are all climate stressors that may impact the San Diego region. A secondary impact of climate change resulting from these and other stressors may include changes in biodiversity, which is an important concern to the City.

All species have ideal ranges for climate conditions and thresholds beyond which their health and survival are impacted. These parameters determine which environments species can inhabit. As climate change shifts the expectations for what local areas may experience in terms of temperature, precipitation, and other climate factors, species may find that their current locations are no longer suitable habitats. In addition, sea level rise and wildfires could markedly change landscapes, destroying existing habitats and creating new ones.

Like humans, other species have several options when it comes to dealing with these changes. Species could migrate, following the changes in environment and climate conditions to stay within habitable zones (Groffman, 2014). For example, in California, fifteen percent of plant species are shifting their habitat ranges to higher elevations. This ability to migrate is more pronounced in non-native species than in native and endemic species, which may disrupt current ecosystem functioning and threaten biodiversity (Hewitt, 2016). However, such shifts are not feasible for many species that are slow-moving or that do not have anywhere to move to (Jennings M. K., 2018). For instance, cold-water-dependent aquatic species, like the southern steelhead and California newt, may already be at the limit of their habitat ranges within the San Diego rivers and creeks (Jennings M. K., 2018).

Species could also adapt and adjust to climate change. For example, many migratory birds in California have started nesting earlier in the spring and migrating later in the fall due to shifts in temperature over the past century (Margolis, 2017; Harvey, 2017)

Species may also experience climate-induced pressures in other ways, such as a mismatch in timing between animals' activities and the availability their food sources, or if species interactions and interdependencies are disrupted by varying responses between the species to climate change (Groffman, 2014).

Not all species would be able to move or adapt, and climate change would bring a number of direct and indirect pressures to ecosystems. Already, climate change is pushing species onto threatened, endangered, and extinct species lists, and the risk of species extinction is projected to increase under climate change (Groffman, 2014). The San Diego region is projected to become less biodiverse in the coming century.

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Appendix B: Hazard Maps

Coastal Flooding

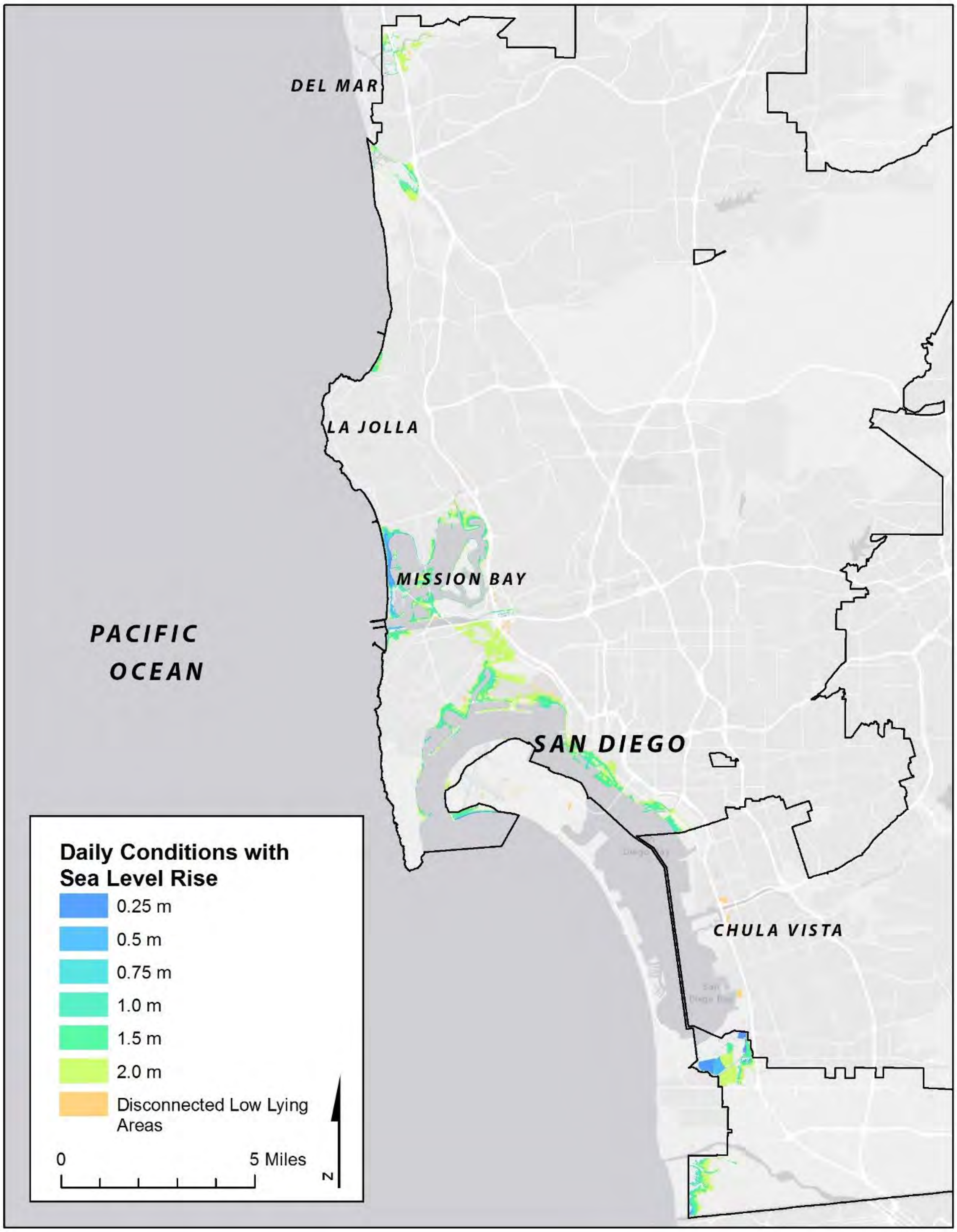

Figure 80. City-wide exposure to average daily flooding at various levels of sea level rise. Flooding data obtained from USGS. Map created: 2019.

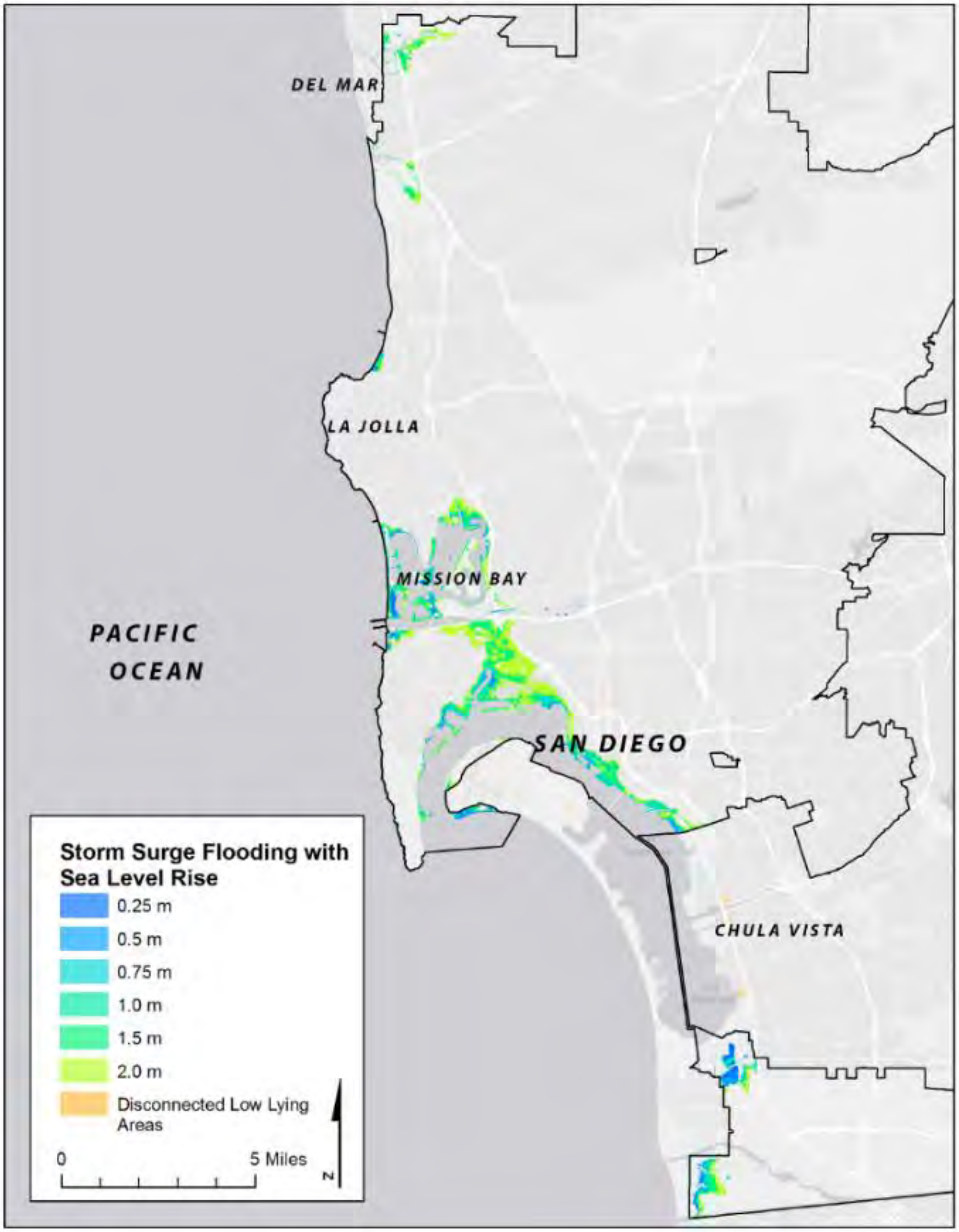

Figure 81. City-wide exposure to storm surge flooding at various levels of sea level rise. Flooding data obtained from USGS. Map created: 2019.

Coastal Erosion

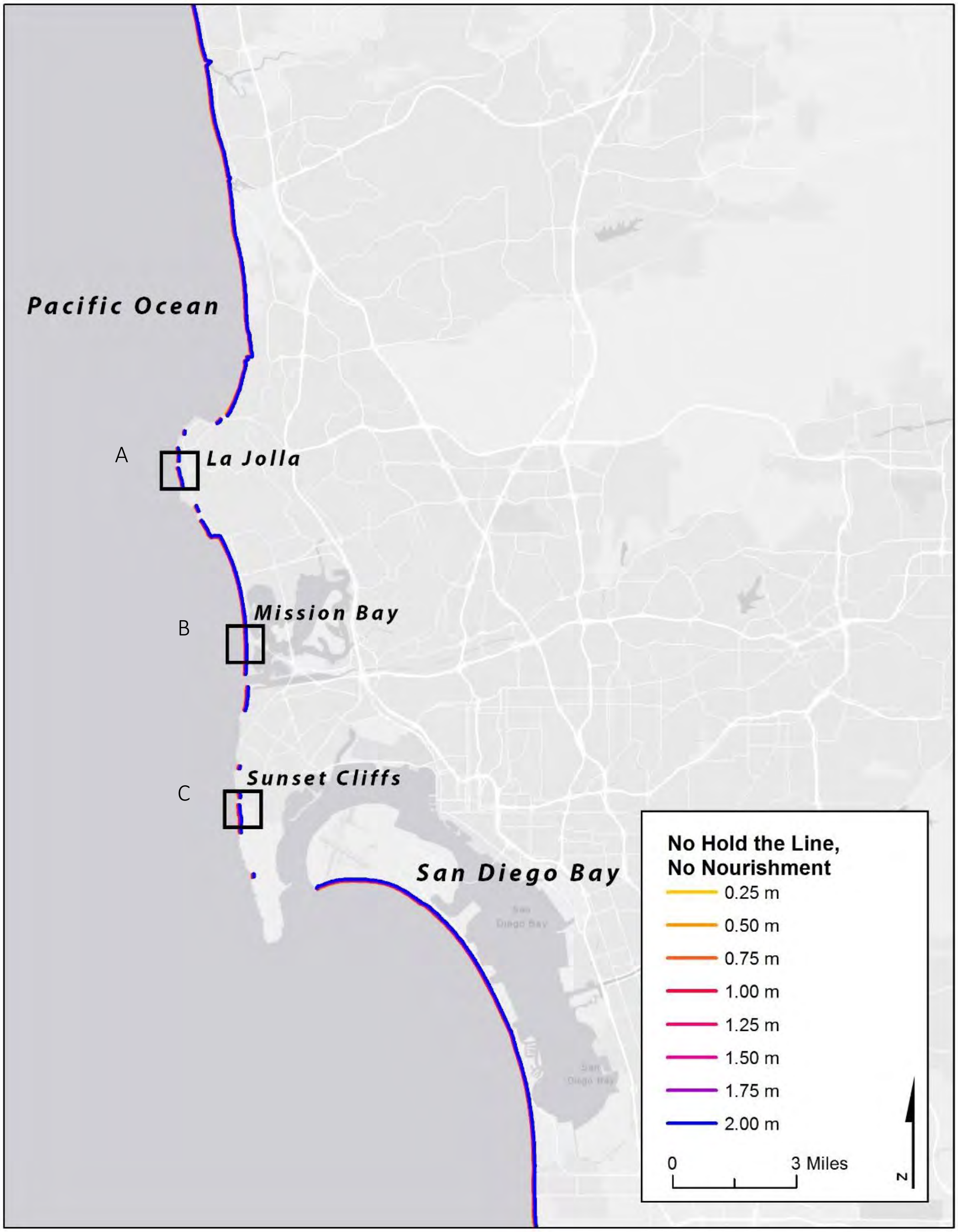

Figure 82. Beach erosion in the City of San Diego. Erosion data obtained from USGS. Map created: 2019.

The various levels of exposure to beach erosion are relatively similar and are difficult to distinguish at this City-wide scale. Three maps at a more detailed extent have been created for La Jolla, Mission Bay, and Sunset Cliffs (as shown by boxes in Figure 82.). In these maps, "No Hold the Line" and "No Nourishment" assumes that current coastal armoring will not be maintained, and the shoreline is allowed to retreat unimpeded and with no increases in sediment. These maps are presented below.

Figure 83. Scenarios of beach erosion given no protection at various levels of sea level rise at La Jolla. Erosion data obtained from USGS. Map created: 2019.

Figure 84. Scenarios of beach erosion given no protection at various levels of sea level rise at Mission Bay. Erosion data obtained from USGS. Map created: 2019.

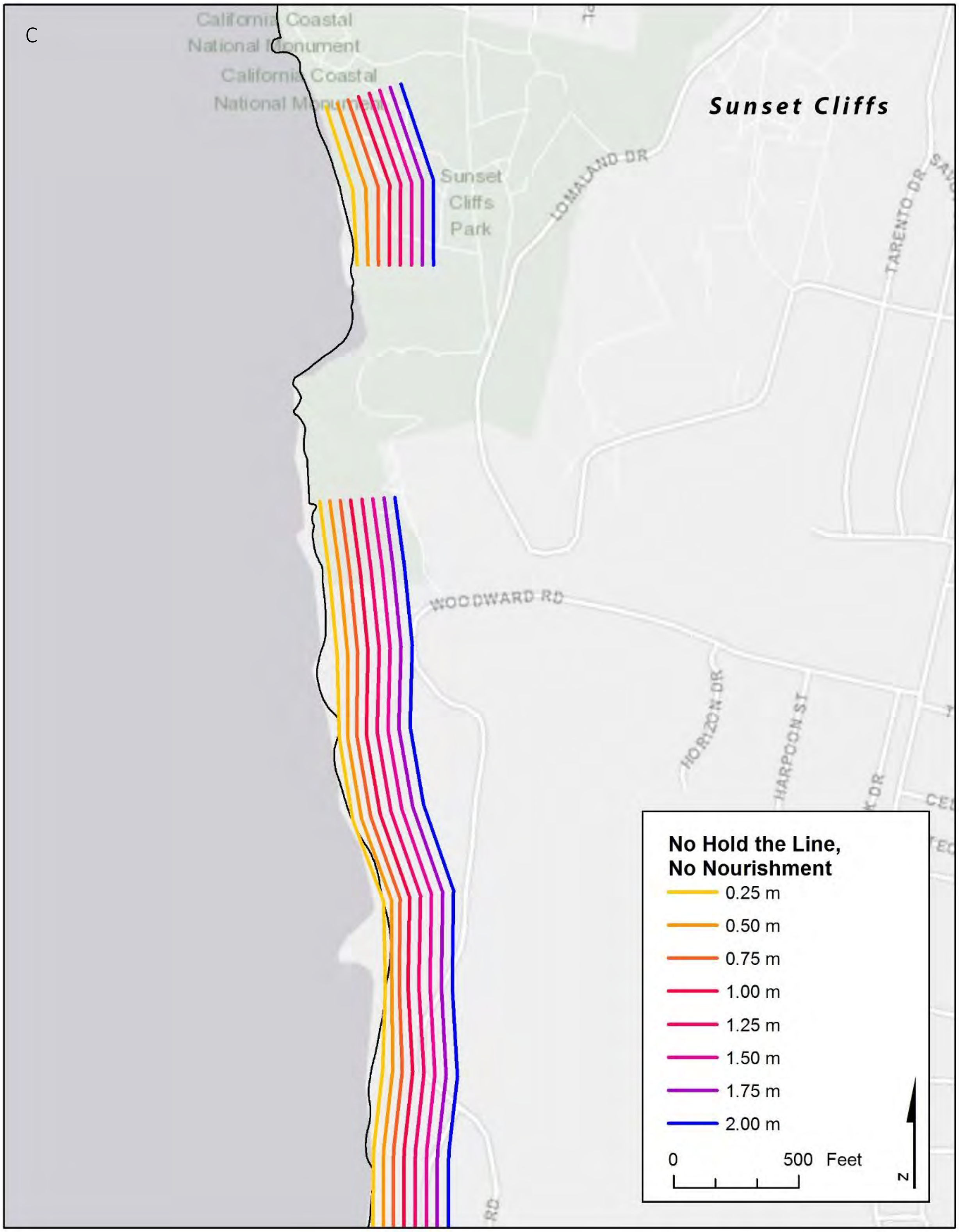

Figure 85. Scenarios of beach erosion given no protection at various levels of sea level rise at Sunset Cliffs. Erosion data obtained from USGS. Map created: 2019.

Precipitation

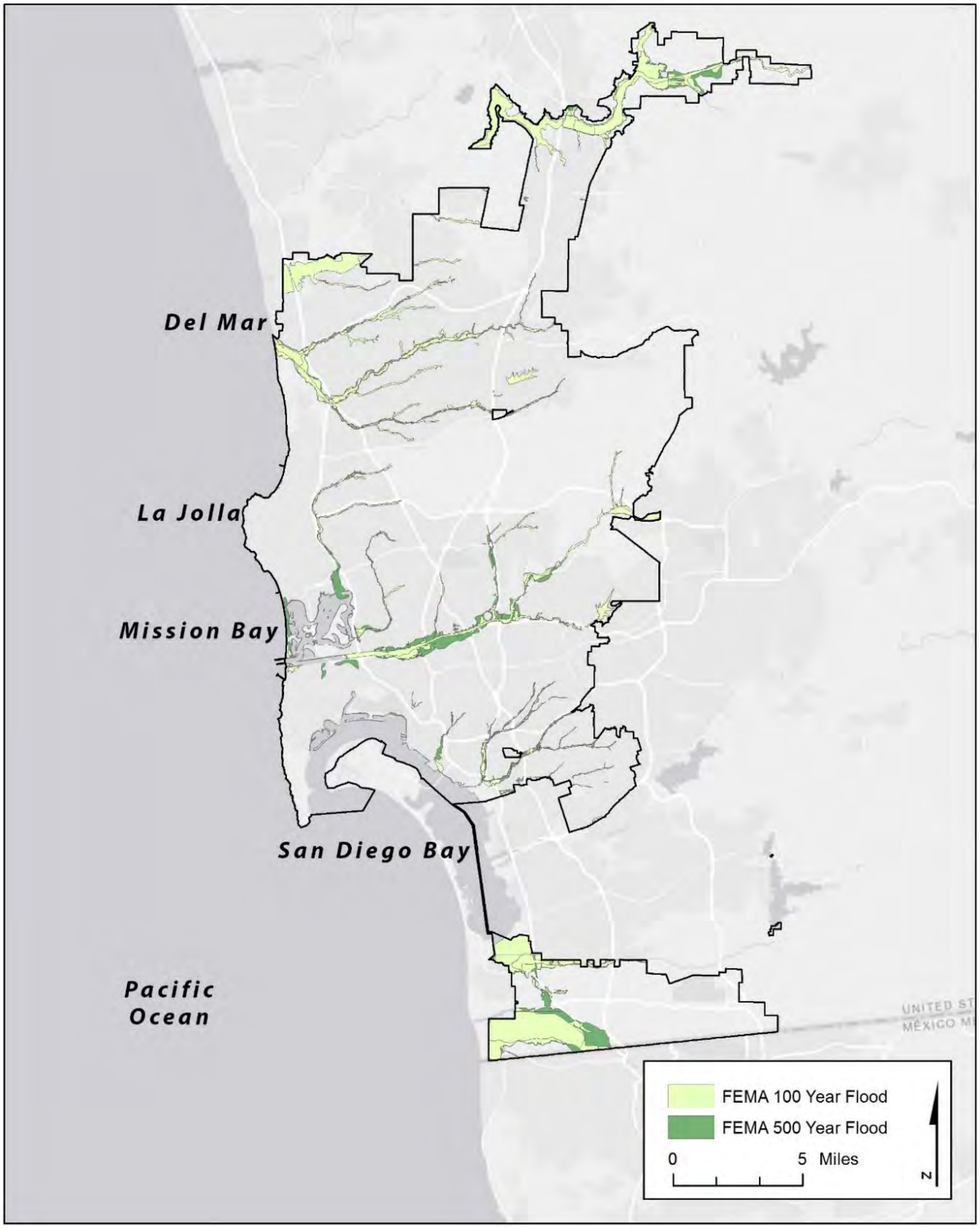

Figure 86. Precipitation exposure to the 100-year and 500-year floods in the City of San Diego. Floodplain data obtained from FEMA. These reflect 2012 FIRMs for all of the City except South Bay, for which the FIRM was last updated in 2016. Map created: 2019.

Wildfire

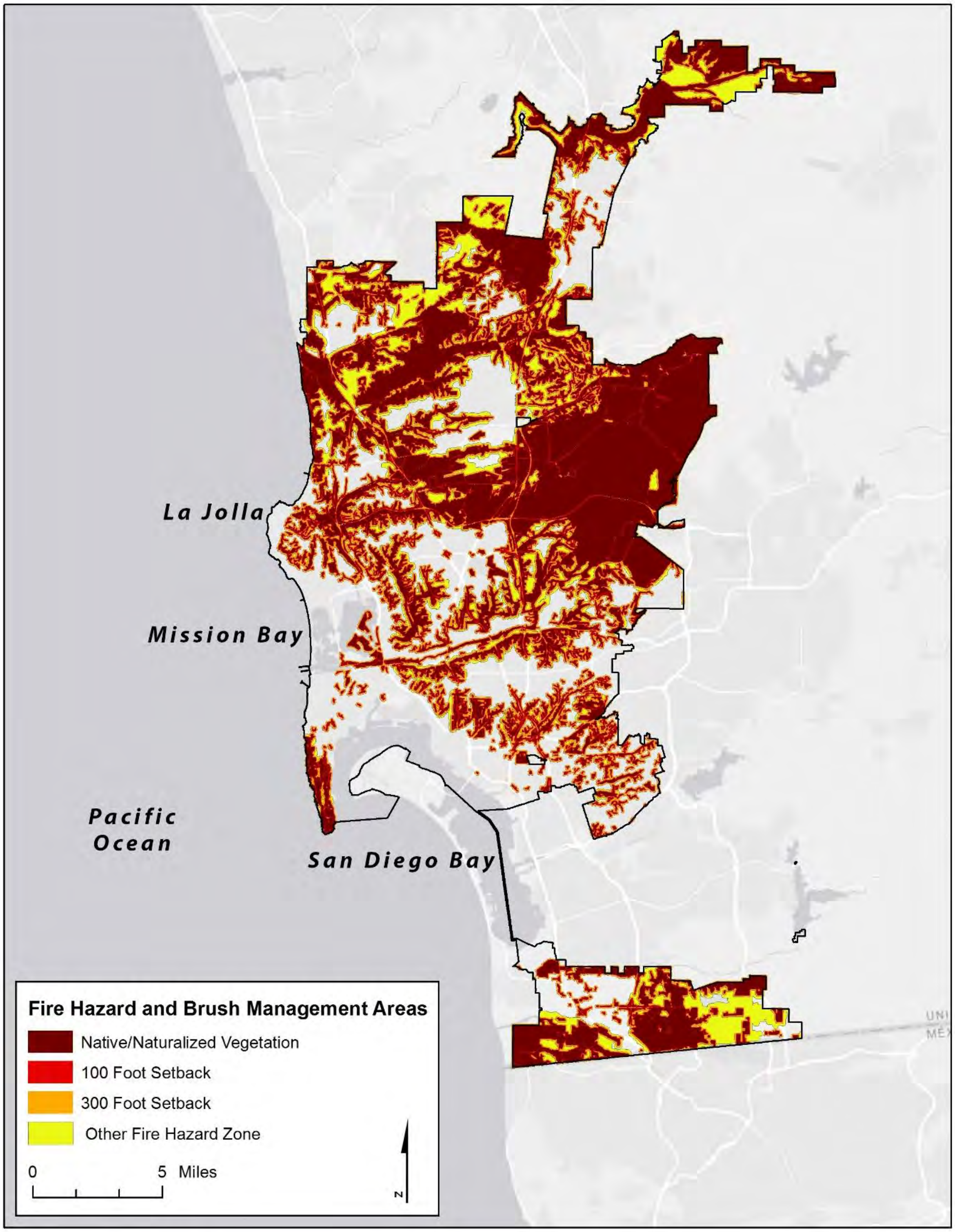

Figure 87. Extent of the wildfire hazard zones in the City of San Diego. Fire hazard zone data obtained from the City of San Diego. Map created: 2019.

Temperature

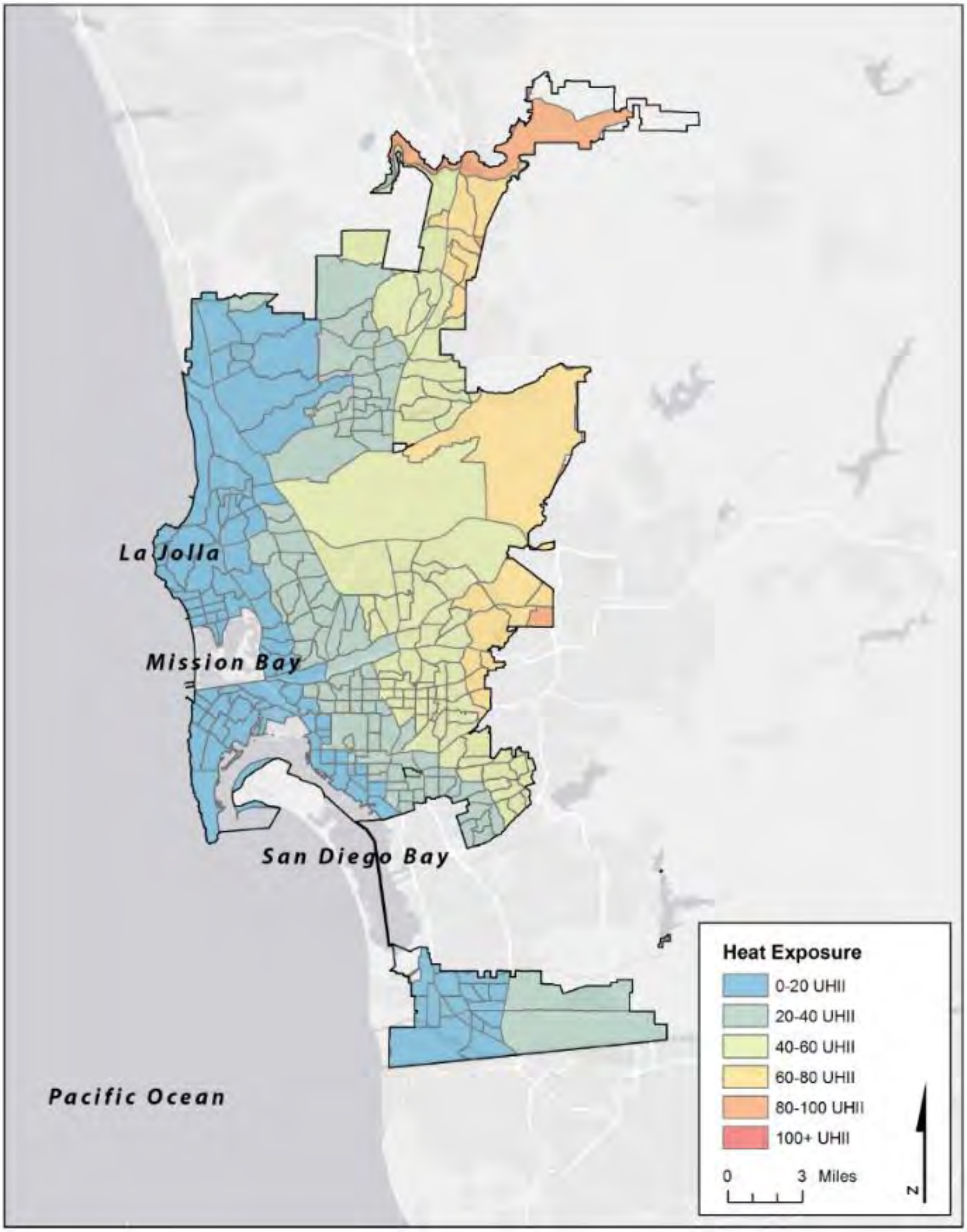

Figure 88. Heat exposure in the City of San Diego given CalEPA's Urban Heat Island Index. Heat exposure data obtained from CalEPA. Map created: 2019.

Appendix C: Exposure Data

This appendix provides more detailed information on the number of assets exposed to each of the climate change hazards.

Sea Level Rise

- **Coastal Flooding**

  According to the November 2018 update to the California Coastal Commission's *Sea Level Rise Policy Guidance,* sea levels in San Diego may rise by 0.6 to 1.1 feet by 2030, 1.2 to 2.8 feet by 2050, and 3.6 to 10.2 feet by 2100 (California Coastal Commission 2018). The City used this information to select corresponding data from localized sea level rise modeling produced by CoSMoS, which were used to develop exposure maps. CoSMoS provides detailed projections of coastal flooding caused by sea level rise and storms while factoring in changes in beaches and the retreat of cliffs and bluffs along the California coast (USGS, n.d.). Table 78 shows how the CCC 2018 projections were translated to the closest data available from CoSMoS.

  Based on this data selection process, the City used the following sea level rise projections to estimate the exposure from daily average flooding and storm surge (100-year) flooding: 0.25 m of sea level rise (2030 timeframe), 0.5 m and 0.75 m of sea level rise (2050 timeframe), and 1.0 m, 1.5 m, and 2.0 m of sea level rise (2100 timeframe). Daily flooding was used to estimate exposure to chronic inundation, and storm surge (100-year storm) flooding was used to estimate exposure to more severe but periodic flooding.

Table 78. Coastal Flooding Scenario Selection Based on CCC 2018 Projections and Closest CoSMoS Increments

Year	Low Risk Aversion Scenario[59] 17% probability SLR meets or exceeds		Medium-High Risk Aversion 0.5% probability SLR meets or exceeds		Extreme Risk Aversion Scenario H++ scenario, no assigned probability	
	CCC 2018 Projection	Closest CoSMoS Increment	CCC 2018 Projection	Closest CoSMoS Increment	CCC 2018 Projection	Closest CoSMoS Increment
2030	0.6 ft.	0.25 m (0.8 ft.)	0.9	0.25 m (0.8 ft.)	1.1 ft.	0.25 m (0.8 ft.)
2050	1.2 ft.	0.25 m (0.8 ft.)	2.0 ft.	0.5 m (1.6 ft.)	2.8 ft.	0.75 m (2.5 ft.)
2100	3.6 ft.	1 m (3.3 ft.)	7.0 ft.	2 m (6.6 ft.)	10.2 ft.	2 m (6.6 ft.)

[59] The recent California Coastal Commission Sea Level Rise Policy Guidance November 2018 update provides three sets of sea level rise projections: low, medium-high, and extreme risk aversion. The sea level rise projections associated with low risk aversion should be used to inform planning for development with high adaptive capacity and relatively low associated consequences if impacted by sea level rise, such as temporary or seasonal development, or development that can be easily moved. The projections labeled “medium-high risk aversion” are appropriate for informing less adaptive, more vulnerable land uses that will experience medium to high consequences if impacted by sea level rise, including residential and commercial development. The projections labeled “extreme risk aversion” and “H++” are appropriate for development that, if impacted by sea level rise, would be irreversibly destroyed, would be significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts—such as critical infrastructure.

- Coastal Erosion

  The relatively soft sandstone bluffs that are common along the San Diego coast are prone to erosion from waves and from storm water runoff. In addition, sea level rise and increased storm frequency has the potential to accelerate beach and other shoreline erosion. The last City-wide coastal erosion assessment, consisting of geotechnical reports, site visits, and photographic documentation of erosion, was completed in 2003 (City of San Diego 2003). The City worked with consultants to update this coastal erosion assessment in 2018 and found that while the City has made improvements to pedestrian access and safety along the erosion sites, due to erosion, more sites pose threats to pedestrians now than in 2003.

  Based on this identified vulnerability, the City selected the best available localized modeling produced by CoSMoS for coastal erosion in the area, covering shoreline and cliff retreat under 2.0 m of sea level rise for four scenarios (USGS, n.d.):

  - Beach erosion:
    - "No hold no nourish" assumes the shoreline is allowed to retreat unimpeded and with no human increases in sediment (i.e., beach nourishment).
    - "Hold, continued nourish" assumes the shoreline retreat is limited to an urban boundary and sediment is increased.
  - Cliff retreat:
    - "Let it go" avoids coastal armoring and allows the cliff to retreat and cliff erosion rates to increase as sea level rises.

For the purpose of this assessment, beach erosion considers erosion of non-cliff shorelines, while cliff retreat considers erosion of cliffs along the coastline.

Coastal Flooding

Table 79. City Critical Asset Type Exposure to Sea Level Rise and Storm Surge

	SLR Scenario	0.25 m		0.5 m		0.75 m		1.0 m		1.5 m		2.0 m	
	Flooding Scenario	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge
Public Safety Assets	Fire Stations (50)	0	0	0	0	0	0	0	0	0	0	0	2
	Police Stations (12)	0	0	0	0	0	0	0	0	0	0	0	0
	Lifeguard Stations (10)	1	1	0	0	0	1	0	1	0	1	1	0
	Fire Logistics and Dispatch	0	0	0	0	0	0	0	0	0	0	0	0

	SLR Scenario	0.25 m		0.5 m		0.75 m		1.0 m		1.5 m		2.0 m	
	Flooding Scenario	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge
	(2)												
	Maintenance Facilities (15)	0	0	0	0	0	0	0	0	0	0	0	0
	Police Patrol and Specialty Vehicles (4)	0	0	0	0	0	0	0	0	0	0	0	0
	Other Public Safety (8)	0	0	0	0	0	1	1	1	1	1	1	1
Water Assets	Dams (7)	0	0	0	0	0	0	0	0	0	0	0	0
	Water Pipes (107,697)	363	428	233	190	197	524	165	280	843	1,131	1,195	991
	Wastewater Pipes (71,563)	330	272	0	264	80	169	554	0	455	516	395	292
	Water Pump Stations (54)	0	0	0	0	0	0	0	0	0	0	0	0
	Wastewater Pump Stations (8)	0	4	0	0	0	0	7	0	0	0	0	1
	Distribution Reservoirs (27)	0	0	0	0	0	0	0	0	0	0	0	0
	Water Treatment Plants (3)	0	0	0	0	0	0	0	0	0	0	0	0
	Wastewater Treatment Plants (4)	0	0	0	0	0	0	0	0	0	0	0	0
Transportation and	Airports (2)	0	0	0	0	0	0	0	0	0	0	0	0
	Bridges (379)	4	4	0	0	0	1	0	2	3	4	4	1

	SLR Scenario	0.25 m		0.5 m		0.75 m		1.0 m		1.5 m		2.0 m	
	Flooding Scenario	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge	Avg. Daily	Storm Surge
	Major Arterials (2,602)	32	44	0	13	2	43	25	23	71	88	117	112
	Drain Pump Stations (14)	1	5	2	0	1	1	1	0	2	0	1	6
	Outfalls (562)	150	202	16	34	29	26	22	18	43	28	25	21
Open Space and Environment Assets	Conservation Areas/Open Space/Source Water Land (118,568 acres)	327.8	178.5	249.6	214.0	220.4	286.3	217.0	278.0	495.1	433.1	558.3	356.8
	Community Parks (11,324 acres)	43.9	67.3	40.4	99.8	72.2	144.9	110.1	136.1	294.8	269.8	259.2	302.4
	Miramar Landfill (1)	0	0	0	0	0	0	0	0	0	0	0	0
	CNG Fueling Station (1)	0	0	0	0	0	0	0	0	0	0	0	0
	Beaches (481.4 acres)	186.6	287.3	24.2	23.5	30.0	28.1	20.5	20.0	47.1	40.3	35.2	30.1
Additional Assets	Recreation Centers (57)	0	0	0	0	0	0	0	0	1	1	0	0
	Libraries (37)	0	0	0	0	0	0	0	0	0	0	0	0
	City buildings (14)	0	0	0	0	0	0	0	0	0	0	0	0
	Historical, Tribal Cultural, and Archaeological Resources (1,375)	7	11	1	1	3	0	0	2	2	3	4	8

Table 80. City Critical Asset Type Exposure to Cliff and Beach Erosion

		Cliff Let It Go	Shoreline Hold, Continued Nourish	Shoreline No Hold, No Nourish
Public Safety Assets	Fire Stations (50)	0	0	0
	Police Stations (12)	0	0	0
	Lifeguard Stations (10)	3	1	3
	Fire Logistics and Dispatch (2)	0	0	0
	Maintenance Facilities (15)	0	0	0
	Police Patrol and Specialty Vehicles (4)	0	0	0
	Other Public Safety (8)	0	0	0
Water Assets	Dams (7)	0	0	0
	Water Pipes (107,697)	89	1	116
	Wastewater Pipes (71,563)	1,221	1,001	67
	Water Pump Stations (54)	0	0	0
	Wastewater Pump Stations (8)	1	2	0
	Distribution Reservoirs (27)	0	0	0
	Water Treatment Plants (3)	0	0	0
	Wastewater Treatment Plants (4)	0	0	0
Transportation and Storm Water Assets	Airports (2)	0	0	0
	Bridges (379)	0	1	0
	Major Arterials (2,602)	1	0	1
	Drain Pump Stations (14)	0	0	0
	Outfalls (562)	85	7	40
Open Space and Environment Assets	Conservation Areas/Open Space/Source Water Land (118,568 acres)	282.2	22.5	85.3
	Community Parks (11,324 acres)	89	26.6	57.2
	Miramar Landfill (1)	0	0	0
	CNG Fueling Station (1)	0	0	0

		Cliff Let It Go	Shoreline Hold, Continued Nourish	Shoreline No Hold, No Nourish
	Beaches (481.4 acres)	71.6	65.6	31.8
Additional Assets	Recreation Centers (57)	0	0	0
	Libraries (37)	0	0	0
	City buildings (14)	0	0	0
	Historical, Tribal Cultural, and Archaeological Resources (1,375)	6	0	7

Table 81. Private Parcel Exposure to Sea Level Rise and Storm Surge

	2030		2050		2100	
Resource (parcels)	Sea Level Rise	Storm Surge	Sea Level Rise	Storm Surge	Sea Level Rise	Storm Surge
Agricultural (1,514)	2	4-5	2-3	5	3-8	8-11
Commercial (8,165)	96-145	159-175	166-175	184-240	188-510	257-618
Community (850)	4-6	6-7	6-7	20-21	20-33	23-36
Cemetery (51)	0	0	0	0	0	0
Entertainment (134)	8	10	8	10	8-14	10-16
Health (512)	0-1	1	1	1-2	1-13	2-19
Hotel/motel (850)	32-35	40-43	37-44	44-491	48-524	495-533
Industrial (3,433)	57	55-56	58-61	58-63	62-169	67-178
Institutional (149)	1	3	1-2	3	3-6	4-9
Marina docks (45)	41	41-42	41-42	42	42	42
Office space (964)	2-6	7-10	10	10	10-11	10-15
Open space (2,375)	2	2	2	2-4	2-9	4-9
Residential (333,199)	1,098-1,848	1,849-2,573	2,223-2,955	3,171-4,228	3,189-5,554	4,875-8,944
Restaurant (706)	27-30	36-37	32-35	40-46	36-81	49-100
Rural land (298)	0	0	0	0	0	0
Not defined (29,956)	521-612	503-580	668-713	619-1,182	734-1,318	1,256-1,546
Vacant (5,457)	49-70	76-84	81-92	88-102	93-161	107-190

Table 82. Private Parcel Exposure to Cliff and Beach Erosion

Resource (Parcels)	Cliff Let it Go	Shoreline No Hold, No Nourish	Shoreline Hold, Continued Nourish

Agricultural (1,514)	3	5	1
Commercial (8,165)	5	3	1
Community (850)	1	0	0
Cemetery (51)	0	0	0
Entertainment (134)	2	2	2
Health (512)	0	0	0
Hotel/motel (850)	3	5	3
Industrial (3,433)	1	0	0
Institutional (149)	3	4	3
Marina docks (45)	0	0	0
Office space (964)	0	0	0
Open space (2,375)	0	0	0
Residential (333,199)	2,504	557	94
Restaurant (706)	4	4	3
Rural land (298)	0	0	0
Not defined (29,956)	50	45	8
Vacant (5,457)	15	18	10

Precipitation

Annual average precipitation projections from Cal-Adapt and other sources suggest only modest changes in total annual precipitation in the decades ahead (Seager, 2015), but there is expected to be more variability in rainfall from year to year and more intense transitions between droughts and deluges (Swain, 2018). To examine potential flooding vulnerabilities from intense precipitation events, the City selected the best available spatial data that reflect current, highly localized precipitation-driven flood vulnerability: the 100-year floodplain and 500-year floodplain from the Federal Emergency Management Agency Flood Rate Insurance Maps (FEMA, 2016). These reflect 2012 FIRMs for all of the City except South Bay, for which the FIRM was last updated in 2016.

Table 83. City Critical Asset Type Exposure to Precipitation-driven Flooding

		FEMA 100-Year Floodplain	FEMA 500-Year Floodplain
Public Safety	Fire Stations (50)	0	1
	Police Stations (12)	0	0
	Lifeguard Stations (10)	1	1
	Fire Logistics and Dispatch (2)	0	0
	Maintenance Facilities (15)	1	1
	Police Patrol and Specialty Vehicles (4)	0	1
	Other Public Safety (8)	0	0
Water	Dams (7)	2	0
	Water Pipes (107,697)	2,299	2,626
	Wastewater Pipes (71,563)	3,328	2,120
	Water Pump Stations (54)	0	1
	Wastewater Pump Stations (8)	2	0
	Distribution Reservoirs (27)	0	0
	Water Treatment Plants (3)	0	0
	Wastewater Treatment Plants (4)	0	0
Transportation and Storm Water	Airports (2)	0	0
	Bridges (379)	15	2
	Major Arterials (2,602)	240	186
	Drain Pump Stations (14)	5	1
	Outfalls (562)	207	76
Open Space and Environment Assets	Conservation Areas/Open Space/Source Water Land (118,568 acres)	12,360.7	1,011.5
	Community Parks (11,324 acres)	573.4	875.3
	Miramar Landfill (1)	0	0
	CNG Fueling Station (1)	0	0
	Beaches (481.4 acres)	92.4	64.3
Additional Assets	Recreation Centers (57)	0	1
	Libraries (37)	0	0

		FEMA 100-Year Floodplain	FEMA 500-Year Floodplain
	City buildings (14)	0	0
	Historical, Tribal Cultural, and Archaeological Resources (1,375)	8	11

Table 84. Private Parcel Exposure to Precipitation-driven Flooding

Resource (parcels)	FEMA 100-year Floodplain	FEMA 500-year Floodplain
Agricultural (1,514)	55	56
Commercial (8,165)	323	706
Community (850)	43	63
Cemetery (51)	5	5
Entertainment (134)	42	42
Health (512)	22	29
Hotel/motel (850)	59	89
Industrial (3,433)	390	552
Institutional (149)	17	21
Marina docks (45)	39	40
Office space (964)	36	59
Open space (2,375)	97	137
Residential (333,199)	6,960	15,087
Restaurant (706)	40	79
Rural land (298)	21	21
Not defined (29,956)	1,489	2,535
Vacant (5,457)	317	481

Temperature

The City used urban heat island index data from the CalEPA to project areas that could be exposed to extreme heat. These data were the best available spatial information for heat within the City at the time of the vulnerability assessment. The geographic patterns revealed by CalEPA's urban heat island data are likely to persist even as temperatures change over time. This source thus identifies areas of the City that are likely to be more or less vulnerable to future extreme heat events. The heat island scenarios are represented as zones with scores of 0 to 100+, with higher scores denoting hotter areas (CalEPA, 2019).[60]

Table 85. City Asset Exposure to Heat. The column ranges represent exposure to different ranges in the UHI index, with higher UHI values denoting hotter areas and therefore increased exposure to heat.

		0-20	20-40	40-60	60-80	80-100	100+
Public Safety Assets	Fire Stations (50)	20	13	12	5	0	0
	Police Stations (12)	6	2	4	0	0	0
	Lifeguard Stations (10)	10	0	0	0	0	0
	Fire Logistics and Dispatch (2)	0	0	2	0	0	0
	Maintenance Facilities (15)	6	2	6	1	0	0
	Police Patrol and Specialty Vehicles (4)	1	1	2	0	0	0
	Other Public Safety (8)	3	1	4	0	0	0
Water Assets	Dams (7)	0	1	3	2	0	2
	Water Pump Stations (54)	7	10	23	13	1	0
	Wastewater Pump Stations (8)	0	1	0	0	0	0
	Distribution Reservoirs (27)	11	3	9	4	1	0
	Water Treatment Plants (3)	0	0	2	1	0	0

[60] The urban heat island index is calculated as a temperature differential over time between an urban Census tract and nearby upwind rural reference points. The index is reported in degree-hours per day on a Celsius scale, a measure of heat intensity over time. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period.

		0-20	20-40	40-60	60-80	80-100	100+
	Wastewater Treatment Plants (4)	2	1	1	0	0	0
Transportation and Storm Water Assets	Airports (2)	0	1	1	0	0	0
	Bridges (379)	180	115	77	4	3	0
	Major Arterials (2,602 segments)	2,480	1,728	1,224	753	458	879
	Drain Pump Stations (14)	14	0	0	0	0	0
	Outfalls (562)	417	77	48	15	1	0
Open Space and Environment Assets	Conservation Areas/Open Space/Source Water Land (118,568 acres)	20,689.2	15,883.6	26,876.6	16,181.6	11,236.6	3,320.9
	Community Parks (11,324 acres)	5,931.3	2772.3	1093	1359.5	91.2	0
	Miramar Landfill (1)	0	0	1	0	0	0
	CNG Fueling Station (1)	0	1	0	0	0	0
	Beaches (481.4 acres)	457.9	0	0	0	0	0
Additional Assets	Recreation Centers (57)	20	20	15	0	1	0
	Libraries (37)	12	11	10	4	0	0
	City buildings (14)	6	1	7	0	0	0
	Historical, Tribal Cultural, and Archaeological Resources (1,375)	832	397	121	1	5	0

Wildfire

Due to uncertainty in the Cal-Adapt wildfire projections, and uncertainty surrounding changes in wildfire drivers, such as fuel availability, fuel moisture, and the Santa Ana winds, the City of San Diego used a conservative approach to plan for a future wildfire risk of equal or greater severity than that of recent decades. The City based its wildfire vulnerability assessment on its four current measures of fire risk: The City's brush management zone, a 100-foot and 300-foot buffer around the brush management zone, and the fire hazard severity zone. These areas indicate where fuel for potential wildfires exists within the City.

Table 86. City Critical Asset Type Exposure to Wildfire

		Native Vegetation	100-ft Setback	300-ft Setback	Fire Hazard Zone
Public Safety	Fire Stations (50)	0	4	5	3
	Police Stations (12)	0	1	1	0
	Lifeguard Stations (10)	0	0	3	0
	Fire Logistics and Dispatch (2)	0	0	0	0
	Maintenance Facilities (15)	0	0	5	2
	Police Patrol and Specialty Vehicles (4)	0	0	1	0
	Other Public Safety (8)	0	0	0	0
Water	Dams (7)	0	1	3	0
	Water Pump Stations (54)	14	18	14	5
	Wastewater Pump Stations (8)	0	0	0	0
	Distribution Reservoirs (27)	2	13	7	1
	Water Treatment Plants (3)	0	0	0	1
	Wastewater Treatment Plants (4)	0	0	3	1
Transportation and Storm Water	Airports (2)	0	1	0	0
	Bridges (379)	73	113	47	10
	Major Arterials (2,602 segments)	24	1,024	527	135
	Drain Pump Stations (14)	0	3	1	1
	Outfalls (562)	85	78	31	22
Open Space and Environment Assets	Conservation Areas/Open Space/Source Water Land (118,568 acres)	69340.2	5616.3	4960.6	6698.9
	Community Parks (11,324 acres)	4,718.3	879	1,071.5	263.9
	Miramar Landfill (1)	1	0	0	0
	CNG Fueling Station (1)	0	0	0	1
	Beaches (481.4 acres)	117.1	23.7	19.4	7.3
Additional Assets	Recreation Centers (57)	1	6	16	4
	Libraries (37)	2	3	2	0
	City buildings (14)	0	2	1	0

		Native Vegetation	100-ft Setback	300-ft Setback	Fire Hazard Zone
	Historical, Tribal Cultural, and Archaeological Resources (1,375)	87	133	268	117

Table 87. Private Parcel Exposure to Wildfire

Resource (parcels)	Native Vegetation/100-ft buffer	300-ft buffer	Fire Hazard Zone
Agricultural (1,514)	307	588	570
Commercial (8,165)	1,279	1,491	1,377
Community (850)	207	290	364
Cemetery (51)	13	22	19
Entertainment (134)	77	75	113
Health (512)	126	154	140
Hotel/motel (850)	86	81	80
Industrial (3,433)	1,246	1,232	1,413
Institutional (149)	40	63	87
Marina docks (45)	0	0	0
Office space (964)	329	369	338
Open space (2,375)	622	1,703	2,616
Residential (333,199)	77,735	152,688	150,821
Restaurant (706)	138	139	127
Rural land (298)	32	128	377
Not defined (29,956)	4,501	6,459	6,724
Vacant (5,457)	949	2,507	3,749

Appendix D: Energy Efficient Buildings

The following buildings have been identified by the City of San Diego as LEED certified (and therefore energy efficient):

Table 88. City-Owned Buildings Identified as LEED Certified

Facility Number	Description	Street	Department Name	Year Built
F2204	Library-New Skyline	7900 Paradise Valley Rd	Library	2016
F2176	Fire Station 17	4206 Chamoune Ave	Fire and Life Safety	2017
F2214	Fire Station 2	825 West Cedar St	Fire and Life Safety	2018
F2224	Fire Station 22	1055 Catalina Blvd	Fire and Life Safety	2018
F2231	Fire Station 5	3902 Ninth Ave.	Fire and Life Safety	2018
F2273	Mission Hills Hillcrest Library	215 W. Washington St.	Library	2018

Appendix C

Coastal Erosion Assessment

City of San Diego Coastal Erosion Assessment Photograph Analysis Update: 2003–2018

Prepared for:

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September 2018

ICF. 2018, City of San Diego Coastal Erosion Assessment, Photograph Analysis Update: 2003–2018 (ICF 00687.17) San Diego CA. Prepared for City of San Diego Planning Department, San Diego, CA.

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Acronyms and Abbreviations

CEA	Coastal Erosion Assessment
City	City of San Diego
LiDAR	Light Detection and Ranging

Executive Summary

In 1993, the City of San Diego commissioned a Coastal Erosion Impact Assessment of the 13 miles of ocean shoreline within its land use jurisdiction. Portions of the shoreline that are not within its jurisdiction, such as federal and Port authority lands, were not included. The 1993 report summarized methods of analysis, interpreted results, and provided long-term rates of cliff retreat. The 1993 report was updated in 2003. [1]

The Coastal Erosion Impact Assessment enables City staff to make informed decisions regarding corrective measures that can be taken, including improvements the City can make to the San Diego coastline. The purpose of this current report is to further update the 71 sites covered in the 1993 and 2003 assessments as part of the development of the City's Climate Adaptation and Resiliency Plan.

In 2018, ICF visited and photographed the sites included in the 1993 and 2003 assessments. Where feasible, photographs were captured with perspectives similar to those taken for the earlier assessments. General observations were recorded and are included herein based on field visits and by comparing the site-specific photographs from 2003 and 2018.

This assessment update found that erosion appears to have affected several pedestrian access ways and staircases, bluffs, and sea caves over the last 15 years. Therefore, a rating scale was developed to help prioritize sites that require additional review. The rating scale contains four levels: *no rating*, and *low, moderate,* and *high priority*. Of the sites, 6% were ranked no rating, 55% were ranked low priority, 18% were ranked moderate priority, and 21% were ranked high priority.

[1] TerraCosta Consulting Group, Inc. 2003. *2003 Coastal Erosion Assessment Update From Sunset Cliffs Park to Torrey Pines State Beach.* City of San Diego Document No.: C-11542. April 2003.

Chapter 1
Introduction

Shore cliff erosion is a common phenomenon in the San Diego region and is driven mainly by sea-level rise, land subsidence, and human impacts. Direct wave impact, salt spray, wind, rainfall, runoff, and people digging and climbing has led to ongoing erosion to the region's bluffs. The continued stress from humans, ground water leakage, and new coastal development requires careful evaluation to ensure community safety and to minimize economic impacts.

In 1993, to address this threat of cliff erosion, the City of San Diego (City) commissioned a Coastal Erosion Assessment (CEA) of San Diego's 13-mile shoreline, from Sunset Cliffs Park in Point Loma to Black's Beach in the Torrey Pines area, a stretch known as the Mission Bay Littoral Cell. The study covered 71 sites, each eliciting several photographs, a risk rating, and site notes. Some of the sites included sub-sites (sites within sites), which were identified with a letter following the site number, and contained separate risk ratings and site notes. The notes provided detailed summary information outlining the site's landscape and suggestions for potential future safety improvements. The 71 discrete sites included bluff-top linear parks, bluff-top streets paralleling the coastal bluff, and City streets that terminate at the bluff edge.

In 2003, the City provided an updated inventory of the 1993 CEA. The 2003 report was a comprehensive assessment of the Mission Bay Littoral Cell and potential areas of concern for the same 71 sites. The report contained a summary table that outlined potential hazards and recommended actions to improve conditions.

The 2003 CEA report utilized a risk rating system that classified sites as either *low, moderate*, or *high risk*. This system was designed to help the City decide what coastal areas are in need of improvement and remediation. In addition, a separate ranking system further detailed the order in which the sites should be addressed. The risk ratings and prioritization were based on field observations and knowledge of conditions that pose the greatest threat to the public. For each site, the analysis provided a brief written description of the site with details of potential hazards, the overall risk rating (low, moderate, high), and the priority ranking of the site (1–71). The analysis also provided photographs with captions depicting changes from 1993 to 2003 conditions. The photographs from 2003 were taken from the same location and vantage point as the 1993 photographs.

The 2003 CEA indicated that erosion along the coastline was prevalent, concluding that 45 sites were at low risk, 17 were at moderate risk, and 9 were at high risk. The 2003 CEA report suggested that enhanced erosion was common amongst the sites. Moreover, the 2003 CEA recommended remedial measures to help lower the risk rating level and improve pedestrian safety: improving pedestrian access ways, adding new vegetation to the area, upgrading corrugated metal drain pipes, and cordoning off certain pedestrian access ways to reduce foot traffic within erosion-heavy areas.

Based on visual inspections undertaken during the preparation of the current report, many of the suggested remediations have been implemented.

2018 Update

This 2018 assessment serves as an update to the 2003 CEA, using site observations and comparisons of photographs to assess how the 71 coastal sites have changed over the last 15 years. The update identifies the apparent changes that have occurred at the various sites through a picture-by-picture analysis and comparison of visual observations to the 2003 pictures, and includes general field observations for each site. The photographs taken in 2018 mimic the photographs taken in 2003 to help highlight the changes. To the extent possible, the picture comparison highlights enhanced erosion, additional fissuring, and additional pedestrian hazards that have taken place from 2003 to 2018 in each site.

Specifically, for each site, one representative site photograph was selected from each of the three studies (1993, 2003, and 2018), and each is compared in a table format that includes a visual analysis, highlighting the general site observations and photographical differences (see Appendix A).

Chapter 2
Methodology

To assess changes to the 13-mile coastline, photographs and observations were taken at the 71 sites from the 1993 and 2003 CEAs. The pictures taken were then compared to those from the same site in the 1993 and 2003 assessments. Access to all sites was achieved by foot or bike; however, some sites could not be accessed due to rusting of pedestrian access ways, no entrance signs in place or public access ways corroded, or seasonal high tides. In these circumstances, a replacement photograph of the general area was taken.

ICF attempted to recreate as closely as possible each of the photographs from the 1993 and 2003 CEAs. To find each of the previous site locations, the site map from the 1993 and 2003 CEAs was used in combination with Google maps. The maps from the previous CEAs identify the exact location of the 71 sites, and are provided in Appendix A. Locations and vantage points for each of the 2018 photographs were then estimated using the previous photo, as well as visual landmarks, trees, and buildings. For example, the photographer might use a specific grouping of palm trees from the 2003 photographs as a landmark to help mimic the 2018 photo.

The site photographs were taken using an iPhone 10 camera. General visual observations at each site were also recorded. Due to bluff damage, certain vantage points from the 2003 CEA were not possible, so a photograph near the vantage point was taken and additional site photographs were incorporated as supplemental material. These supplemental photographs were not used as the "representative site photo" for any of the sites in the analysis. Depending on the severity of the erosion of the site, an additional representative site photograph was taken. At the end of each site write up, there is a short bulleted summary of site observations. These were used in combination to help classify the site priority.

Many of the site memos in the 2003 CEA contained sub-sites, denoted using letters (e.g., 9A and 9B). The 2003 CEA included the sub-sites to create a more holistic evaluation of each site. The sites tended to contain multiple areas, bluffs, and access ways, and as a result needed to be split into separate sub-sites. Each sub-site represents a different part of the site. Certain sites contain multiple bluffs and require multiple site evaluations to capture the holistic state of the site. Consequently, within the 2003 CEA several of the sub-sites contained different risk ratings. For ICF's site priority analysis, most of the sites contained a single priority rating (i.e. no sub-sites). The photographs from the sub-sites were included in the supplemental section of each site write-up. ICF chose to include additional sub-site comparison write ups for only two of the sites (9 and 71), consistent with the 2003 CEA. For the data analysis section, ICF selected the higher priority rating between the sub-sites. For example, if site 71A and 71B were rated high and moderate, then ICF would choose the high rating for the analysis section. The same issue occurred with the 2003 CEA risk priority rating; ICF took the higher rating from that section as well for its final analyses.

Priority Rating System

In the previous 2003 CEA, the risk rating system assigned the sites as low, moderate, and high risk. This system assessed site ratings based on geological observations and assessment rather than on specific criteria.

The 2018 did not undertake a geological analysis, and instead focused on visual observations of bluff condition and human use of the sites. As a result, ICF developed a *priority* rating system to help the City develop remedial action focused on personal risk, while also taking into consideration the previous geologically based CEA *risk* rating. The priority rating was split into no rating, low, moderate, and high.

The 2018 priority rating was based on whether the representative site photograph contained certain specific criteria, as outlined in Table 2-1. ICF used the criteria in Table 2-1 to establish the priority rating for each site. As noted above, some sites could not be accessed due to seasonal high tide or poor pedestrian access. In those instances a photograph from a different vantage point was taken, and the site received a priority rating of "no rating."

- A low priority rating site showed no changes since 2003 or contained no potential pedestrian hazards.
- A moderate priority rating site displayed marine and subaerial erosion, residential areas next to a bluff edge, and/or rusting of pedestrian access ways.
- A high priority rating site has potential pedestrian hazards, no access to the site because of poor pedestrian access ways, and signs of imminent bluff collapse that may affect pedestrians or residential areas.

Many sites contained both high and moderate priority criteria. In these cases, the site was labeled as a high priority site. Similarly, if a site contained both moderate and low priority criteria it was considered a moderate priority site.

Table 2-1. Site Priority Rating System

Priority Rating	Specific Criteria for Each Site Category
No Rating	• Previous vantage point could not be accessed • Representative photograph was taken in its place
Low	• No major changes since 2003, and the site was previously stated in the 2003 CEA as "good," "stable," "great," or another term suggesting safe conditions • Appears to pose no threat to pedestrians • Appears to be minor marine and subaerial erosion
Moderate	• Appears to be marine and subaerial erosion • Corrosion of pedestrian access ways • Residential areas next to bluff edge, but bluff appears to be stable • Warning signs about cliffs and bluffs • Appears to be minor cracks in the pedestrian access ways
High	• Pedestrian hazards • No access to the site because of poor pedestrian access ways • Signs of imminent bluff collapse that could affect pedestrians or residential areas

Chapter 3
Results

Appendix A provides a summary table containing the site number, site location, overall risk rating from the 2003 CEA, the new priority rating, and explanation of each site's specific criteria. The specific criteria were utilized to determine the priority rating. The table summarizes observed issues from each site while referencing information from the 2003 CEA.

Analysis

For the purposes of the analysis of site priority changes, it is acknowledged that the site priority (risk) ratings in the 2003 CEA and those used in this report were not based on the same process, as outlined above.

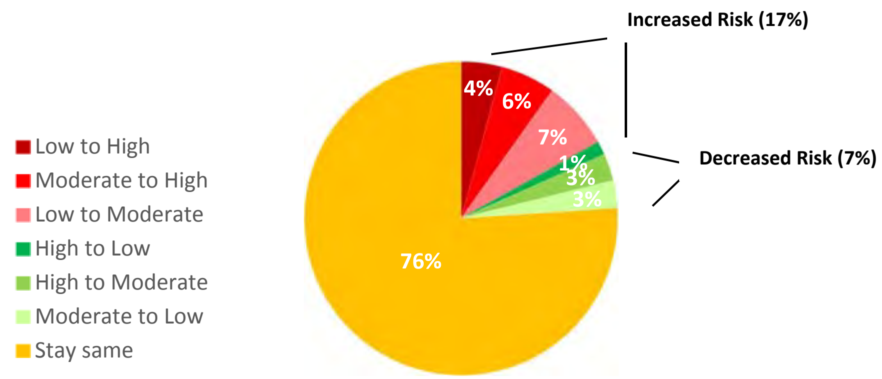
Table 3-1 highlights the number of sites that fall within each of the priority categories (no rating, low, moderate, and high priority). Additionally, the table includes the percentages of the 71 sites by risk category. The table also compares the percentage difference between the 2003 overall risk rating and the new priority rating used in this report. The percentage statistics were calculated using a total of 71 sites.

Table 3-1. Priority and Risk Site Ratings

	Low	Moderate	High	No Rating
2003 CEA Overall Risk Rating	46	13	12	N/A
New Overall Risk Rating	39	13	15	4
Percentages from 2003 CEA Overall Risk Rating	65%	18%	17%	0%
Percentages for New Overall Risk Ratings	55%	18%	21%	6%
Percentage Change	10%	0%	-4%	N/A

Figure 3-1 highlights the changes in site priority rankings from the 2003 CEA to the 2018 update in this report. The site priority increases are a sum of the low to high, moderate to high, and low to moderate changes in site priority rating. The site priority decreases are a sum of the high to low, high to moderate, and moderate to low site priority rating changes. The percentage statistics were calculated out of 71 sites.

FIGURE 3-1: PRIORITY RATING CHANGES FROM 2003 TO 2018



The intention of the study was to help the City determine the sites that pose the greatest threat to pedestrians frequenting the coastal sites. Of the 71 sites, 4 were labeled no rating, 39 were labeled low priority, 13 were labeled moderate priority, and 15 were labeled as high priority according to ICF's priority rating scale. ICF could not determine a priority rating for the 4 no rating sites because the sites lacked adequate access. The City may want to investigate the condition of the 4 sites when tidal conditions and proper permit access allows. Moreover, ICF chose to combine sub-sites from the same site for the purposes of the analysis. Within the result section, the sub-site with the higher rating was recorded for the analysis statistics.

Table 3-1 highlights a 10% reduction in low priority sites. This decrease could be due to the inclusion of a no rating site priority ranking in the 2018 update. Moreover, Figure 3-1 indicates that 8 sites moved from low to either moderate or high priority rankings, while only 3 sites went from a site priority rating of moderate or high to low. Figure 3-1 highlights a 17% increase in site priority rating, and a 7% decrease in site priority rating, which loosely suggests an overall increase in site risk.

Chapter 4
Discussion

The City appears to have made numerous changes to the sites' pedestrian access ways since 2003. For example, Site 35 previously had a PVC low height railing staircase. The PVC staircase seems to have been replaced with a protection barrier staircase. Because the new protection barriers are higher than before, the staircase provides more protection from high tides. Many of the access ways are created around or within the eroding bluffs. The staircases usually contained joint foundations that are rooted in the bluffs. In Site 16, there appear to be fractures forming within the joint foundations of the access way. There also appears to be minor marine and subaerial erosion that continues to change the stress tensions of the staircase. The change in stress tensions may lead to the further deepening of already present cracks or may create new fractures.

Another common development within pedestrian access ways was the erosion of staircase railings, which appear to be corroding due to overexposure to marine erosion, subaerial erosion, and consistent pedestrian usage. The 2003 Site 18 representative photograph suggests that there previously was a staircase railing adjacent to the staircase. In the 2018 Site 18 representative photograph, the staircase railing appears to have been removed or eroded away.

Collapsing bluffs are also an observed risk to pedestrians. The Site 7 representative photograph suggests the bluff has experienced minor collapse and the pathway along the bluff has nearly eroded away. The erosion appears to approach the pedestrian barriers and road.

Another common pedestrian hazard identified among the 71 sites are sea caves. Site 62 is a sea cave that has a lookout viewpoint directly above it. At the time of observation, there were many swimmers and kayakers exploring the scenic area in the sea cave at Site 62. The cave is around 200 meters high and appears to be eroding. At the top of the cliff there is an area restrictive sign at the edge of the sea cave preventing entry to pedestrians. However, it is clear that many pedestrians ignore the sign and walk directly onto the hazardous area on the arch immediately above the sea cave.

Coastal users typically ignore area restrictive signage. Several sites include new signage explaining that pedestrians are not allowed access. For instance, Site 2 contains a “Do Not Enter” sign at the entrance to the stairwell. Observations confirm that pedestrians ignore the sign and use the stairwell despite the warning sign. This particular pedestrian access way leads to a heavily eroded and rocky beach front.

In addition, certain sites do not contain pedestrian access ways. The photographs from Sites 33 and 34, for example, could not be reproduced due to the lack of a pedestrian access way or path at the base of the bluffs.

Chapter 5
Conclusion

The 2018 photograph update assessment found that erosion and hazards to coastal users remain prevalent along the Mission Bay Littoral Cell. Since 1993, the City has made many improvements to the 71 sites, seeking both to reduce erosion risk and enhance public safety along the coastline. Despite these noticeable efforts, problems still exist along the coast.

Of the 71 sites, 4 were labeled no rating, 39 were labeled low priority, 13 were labeled moderate priority, and 15 were labeled as high priority according to the priority rating scale developed for the 2018 update. Since the 2003 assessment, 5 of the 71 sites have shown obvious improvement in terms of risk. These improvements are mostly due to efforts by the City to mitigate signs of erosion and risks to pedestrians. While there are some signs of progress, the 2018 assessment found that there were more instances of increased risk than decreased risk among the sites. Twelve out of the 71 (17%) of the sites had evidence of increased erosion and increased risk to pedestrians. The four most common problems identified were the risks to pedestrian staircases, collapsing bluffs, potential weakening of sea-cave arches, and lack of pedestrian access ways in some locations. These issues seem to be compounded by pedestrians' disregard for restrictive signage. The majority of the sites (76%) appeared to be in the same condition as the previous 2003 assessment.

ICF recommends that the City use this photograph analysis and accompanying priority ratings as a guide for future improvements to the coastline. The 12 sites that have shown increased risk, and those that remain high risk from the 2003 CEA, are starting points for consideration. Ultimately, internal coordination at the City is needed to establish how these results are used, what departments should be engaged, the timing of improvements, and frequency of future updates. At a minimum, the photograph analysis here should be updated within 10 years (2028).

In addition to the periodic (10-year) update, it is recommended that the City explore alternative methods of data collection, including but not limited to, citizen science. Citizen science is the use of the general public in the collection and analysis of data related to various research questions. In this case, the City can engage the public to assist with collection of photographs for their on-going monitoring of coastal erosion. It is clear that many of the sites included in the CEA are highly trafficked. It is likely that visitors are already taking photographs at these sites on a regular basis, and likely sharing these photographs on various social media platforms. The City can take advantage of this through signage encouraging the public to share their photographs to contribute to the CEA updates. In addition to public contribution, it is possible that City staff and departments that frequent these coastal sites can also contribute to the monitoring efforts. Both approaches would require varying levels of coordination and resources.

As indicated above, this 2018 update was a high-level photographic analysis. As time and resources permit, the City should prioritize a more technical analysis from which site-level erosion and site management conclusions can be drawn. In a recent publication in *Geomorphology,* a researcher from Scripps demonstrated the ability to employ Light Detection and Ranging (LiDAR) remote sensing technology for the purposes of monitoring coastal cliff erosion in California. The 2018 study found that between 1998 and 2009/2010, unarmored cliff faces along the California coast retreated 0.05

meter per year compared to armored cliff faces.[2] The techniques used in this study could be used at the City level to more precisely evaluate erosion and the advantage of specific remediation techniques. ICF recommends that City staff pursue funding and opportunities to collaborate with Scripps to test LiDAR technology for these purposes.

Overall, the data collected here serves as a guide for the City to determine the sites that require their attention. The data consists of qualitative and general observations that should encourage the City to prioritize certain sites and to take actions to remedy the sites that are in greatest need.

[2] Young, A. P. 2018. Decadal-scale Coastal Cliff Retreat in Southern and Central California. *Geomorphology*, 300,164–175.

Appendix A
2018 Photograph Analysis

Table A-1 summarizes the study sites, giving the site number, location, overall risk rating from the 2003 CEA, the new priority rating, and an explanation of each site's specific criteria. The specific criteria were utilized to determine the priority rating. The table summarizes observed issues from each site while referencing information from the 2003 CEA.

Table A-1. Summary Table of Sites Including the New and Old Risk Rating

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
1	Sunset Cliffs Park	Low	Low	• No major changes since 2003 • Area deemed a low risk in 2003; minimal subaerial erosion • The photograph suggests no major potential pedestrian hazards
2	Ladera Street Access Stairway	Moderate	No Rating	• Pedestrians illegally cross to access the area; there seems to be a large sign that says "No pedestrian access" above a staircase • Once at the bottom the area contains slippery rocks to access the other sides of the beach • Could not access same vantage point due to seasonal high tide
3	Ladera Street to Carmelo Street	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
4	Carmelo Street to Monaco Street	Moderate	Moderate	• Marine and subaerial erosion appears to approach the street protection barrier
5	Monaco Street to Hill Street	Low	Low	• Major erosional changes • Area deemed a low risk in 2003 • No pedestrian hazards since area is fenced off 4 feet from the erosion; the lack of effect on pedestrian livelihood is why the site received a low priority rating

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
6	Hill Street to Guizot Street	High	High	• Erosion appears to approach the street protection barrier • Formation of new fractures along the bluff • Erosion interfering with pedestrian access ways • In 2003 the site was deemed a high risk
7	Guizot Street to Froude Street	High	High	• Erosion appears to approach the street protection barrier • Formation of new fractures along the bluff • Erosion interfering with pedestrian access ways • In 2003 the site was deemed a high risk
8	Froude Street to Osprey Street	High	High	• Erosion appears to approach the street protection barrier • Formation of new fractures along the bluff • Erosion interfering with pedestrian access ways • In 2003 the site was deemed a high risk
9A	Osprey Street to Adair Street	High	Moderate	• Improvements have been made to the area • There seems to be a new “Stay Back” sign
9B	Osprey Street to Adair Street	Low	Low	• No major changes since 2003 • The photograph suggests no major potential pedestrian hazards • The previous CEA confirmed the pipe as “stabilized”
10	Adair Street to Point Loma Avenue	Low	High	• Bluff to the north of the building appears to display less vegetative cover than before. • The bluff north of the residential area appears to experience subaerial erosion • Sedimentary mass from the upper face of the bluff appears to have fallen to the bottom
11	Point Loma Avenue to Bermuda Avenue	High	High	• Could not access the sea caves within the area • There is a steep cut off pedestrian access way that requires pedestrians to jump

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
				1 meter down to access the caves and the beach end • The weigh bags have completely replaced the bluff
12	Bermuda Avenue to Pescadero Avenue	Moderate	High	• Could not access the base of the staircase • There is a steep cut off pedestrian access way that requires pedestrians to jump 1 meter down to access the caves and the beach end • There appears to be marine and subaerial erosion approaching the wooden fence
13	Pescadero Avenue to Orchard Avenue	Low	Low	• High tide prevents pedestrians from venturing down to the beach • Change in height of pebbles from edge of the access way by the staircase creating a steep drop off
14	Orchard Avenue to Coronado Avenue	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
15	Coronado Avenue to Santa Cruz Avenue	Moderate	Moderate	• The pedestrian access way is slippery and angled in a way that makes pedestrians prone to slip • Change in slope angle suggests more pressure at the base
16	Santa Cruz Avenue to Del Monte Avenue	Moderate	Moderate	• There seem to be cracks at the joints of the stairs • Marine and subaerial erosion encroaching underneath the cement pedestrian walkway
17	Del Monte Avenue to Narragansett Avenue	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
18	Narragansett Avenue to Newport Avenue	Moderate	Moderate	• There appears to be slight marine erosion • The pedestrian staircase does not include a railway

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
19	Newport Avenue to Saratoga Avenue	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
20	Saratoga Avenue to Brighton Avenue	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
21	Brighton Avenue to San Diego River	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
22	Mission Beach Park	High	Low	• The beach barriers appear to be fixed • There appears to be no major signs of erosion • The photograph suggests no major potential pedestrian hazards
23	South Pacific Beach	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
24	Garnet Avenue	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
25	Felspar Street to Diamond Street	Moderate	Moderate	• There appears to be marine and subaerial erosion • Heavy pedestrian usage • Wooden reinforcement barrier, concrete infills along the entire site
26	Diamond Street to Missouri Street	High	High	• The staircase support structures are built within a

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
				bluff that show signs of enhanced erosion • Heavy pedestrian usage within the area, which is why the site has a high priority rating
27	Missouri Street to Law Street	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
28	Law Street to Loring/Ocean Street	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
29	Loring/Ocean to Tourmaline Street	Low	Low	• There appears to be a slight change in the slope angle, but that is due to the sand berms naturally spreading out over time • There appear to be no major pedestrian hazards • The corrugated metal pipe (CMP(storm drain shows no signs of cracks
30	Tourmaline Surfing Park	Low	Low	• The cobble-berm at the beach has resulted in less water reaching the base of the bluffs by Tourmaline Surfing Park • There appear to be no imminent pedestrian hazards within the area
31	Tourmaline Street to Calumet Pedestrian Access	Moderate	High	• Once past the pedestrian access way it seems to be dangerous to walk along the slippery and mossy rocks • There are signs of erosion along the stretch • There are many “stay back from the cliffs” signs next to the pathway to the staircase
32	Caulmet Park to Midway Street	Low	No Rating	• The pedestrian access way appears to be incredibly slippery and narrow • In the pathway along the beach there appear to be many mossy

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
				rocks and well-rounded large rocks, which makes it hard to walk across the site
33	Midway Street to Forward Street	Low	No Rating	• Could not access the pedestrian pathway due to hazardous conditions to reach the representative photograph location • Many residential areas atop the bluff that are combating bluff erosion with wooden reinforcements
34	Forward Street to Bird Rock Avenue	Low	No Rating	• Could not access the pedestrian pathway due to hazardous conditions to reach the representative photograph location • Many residential areas atop the bluff that are combating bluff erosion with wooden reinforcements
35	Bird Rock Avenue to La Jolla Hermosa Park	Low	Low	• Major changes made to the staircase to raise the height of the railings, to replace PVC with concrete • There appear to be no signs of major bluff erosion
36	La Jolla Hermosa Park to Sun Gold Point	Low	Low	• The City has effectively cordoned off the pedestrian access way to the ocean • The 2003 CEA described the area to be in “excellent condition”
37	Sun Gold Point to Cortez Place	High	Moderate	• The access way down to the site appears to have a new railing since 2003 • The surrounding area is still subject to marine and subaerial erosion • There seems to be corrosion on the edge of the staircase
38	Cortez Place	Low	Moderate	• There appears to be marine and subaerial erosion • Staircase railings are experiencing corrosion

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
39	Palomar Avenue to Rosemont Street	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
40	Rosemont Street to Kolmar Street	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
41	Kolmar Street to Gravilla Street	Moderate	Low	• No major changes to site since 2003 • The street drain appears to be upgraded • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
42	Gravilla Street to Playa Del Sur	Low	Low	• No major changes to site since 2003 • The staircase appears to have been redone since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
43	Playa Del Sur to Playa del Norte	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
44	Playa Del Norte Bonair Street	Low	Low	• No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
45	Bonair Street to Nautilus Street	Low	Moderate	• The bluff appears to have marine and subaerial erosion • The erosion approaches the pedestrian access way

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
46	Nautilus Street to Westbourne Street	High	Low	• Sand level rises to the edge of the storm drain • No major changes to site since 2003 • Area deemed a low risk in 2003 • The photograph suggests no major potential pedestrian hazards
47	West of Vista Del La Playa	Low	Low	• No major changes to site since 2003 • Area deemed as low risk in 2003 • The photograph suggests no major potential pedestrian hazards
48	Sea Lane Street End	Low	Moderate	• The pedestrian access way to the beach seems to be a little steep • The access way appears to be a narrow path
49	Marine Street End	Low	Low	• 2003 CEA labeled the ramp to be in “good” condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
50	North of Marine Street	Low	Low	• 2003 CEA labeled the drainpipe to be in “reasonable” condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
51	Coast Boulevard South of La Jolla Boulevard	Low	Low	• 2003 CEA labeled the viewpoint to be in “reasonable” condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
52	Coast Boulevard Park	Low	Low	• 2003 CEA labeled the staircase to be in “good” condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
53	Coast Boulevard Park at Cuvier Street	Low	Low	• No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
54	Coast Boulevard by South Casa Beach	Low	Low	• High pedestrian usage on an eroding bluff that encroaches the edge • The photograph suggests that the bluff has experienced marine and subaerial erosion
55	Coast Boulevard Split to Children's Beach	High	High	• The bluff trail is narrow and dangerous to pedestrian access with many uneven patches • There appear to be many wooden reinforcements and human-made bluff retreats around this area
56	Children's Beach Seawall	Low	Low	• 2003 CEA labeled the access way to be in “good” condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
57	Coast Boulevard At Children's Beach	Moderate	Low	• 2003 CEA labeled the staircase to be in “good” condition • No apparent pedestrian hazards within the phot
58	Coast Boulevard-Jenner Street to Ellen Browning Scripps Park	Moderate	Moderate	• There appears to be marine erosion and wave erosion at the base of the cliffs
59	Ellen Browning Scripps Park	Low	Low	• The fence appears to have been removed since 2003 • The area appears to have experienced little to no erosion since 2003 • There does not seem to be any major signs of erosion
60	La Jolla Cove	Low	High	• The sea cave appears to show several signs of potential collapse • Heavy corrosion on the ceiling of the cave • Enhanced marine and subaerial erosion

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
61	Coast Boulevard La Jolla Cove	High	High	• There appears to be erosion near pedestrian trails and along coastline • Many residential areas atop the bluff, and cracks forming on the road
62	La Jolla Cove (North of 1325 Coast Boulevard)	High	High	• Massive sea cave seems to be on the cusp of collapsing where hundreds of pedestrians kayak and swim across • Many pedestrians access the top of the sea cave • The ceiling of the cave appears to be thinning
63	Coast Walk (Bluff Top Trail)	Moderate	High	• Signs of marine and subaerial erosion • There appears to be the formation of sea caves • Appears to be vegetation loss on the bluff
64	Coast Walk to End of Foot Bridge	Low	High	• Bluff at the end of the trail appears to have slightly collapsed • The access way seems to have been redone, but the old access way still exists
65	South of La Jolla Shores	Low	Low	• The CEA 2003 report labeled the aging seawall to be in “good” condition • Fracture above sea cave due to enhanced marine and subaerial erosion • Pedestrian access way seems to contain moss
66	Roseland Drive to Paseo Drive	Low	Low	• The CEA 2003 report labeled the aging seawall to be in “good” condition • There seems to be a fracture above sea cave • Pedestrian access way seems to contain moss
67	Avenida De La Playa to Vallecitos	Low	Low	• 2003 CEA labeled the staircase to be in “good” condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003

Site Number	Site Location	Overall Risk Rating from the 2003 CEA	New Priority Rating	Explanation
68	La Jolla Shores Beach/Kellogg Park	Low	Low	• 2003 CEA labeled the sea wall to be in “good” condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
69	Beach View Park (9000 La Jolla Shores Lane)	Low	Moderate	• No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003 • Proper signage around the area, and old trail is now under construction for a new building
70	Citizen Trail to Black's Beach from Gliderport	Low	Moderate	• There appears to be marine and subaerial erosion within the site • Pedestrian barriers have collapsed down as the edge of the bluff has eroded away
71A	Black's Beach	Moderate	High	• Many of the respective areas of the staircase have already been improved here but there still appear to be unsupported human-made structures and segments that pose a risk to pedestrians accessing the path
71B	Black’s Beach	Moderate	Moderate	• There appears to be marine and subaerial erosion within the site • Area deemed as low risk in 2003 • The bluff on the right appears to have collapsed slightly

Figures

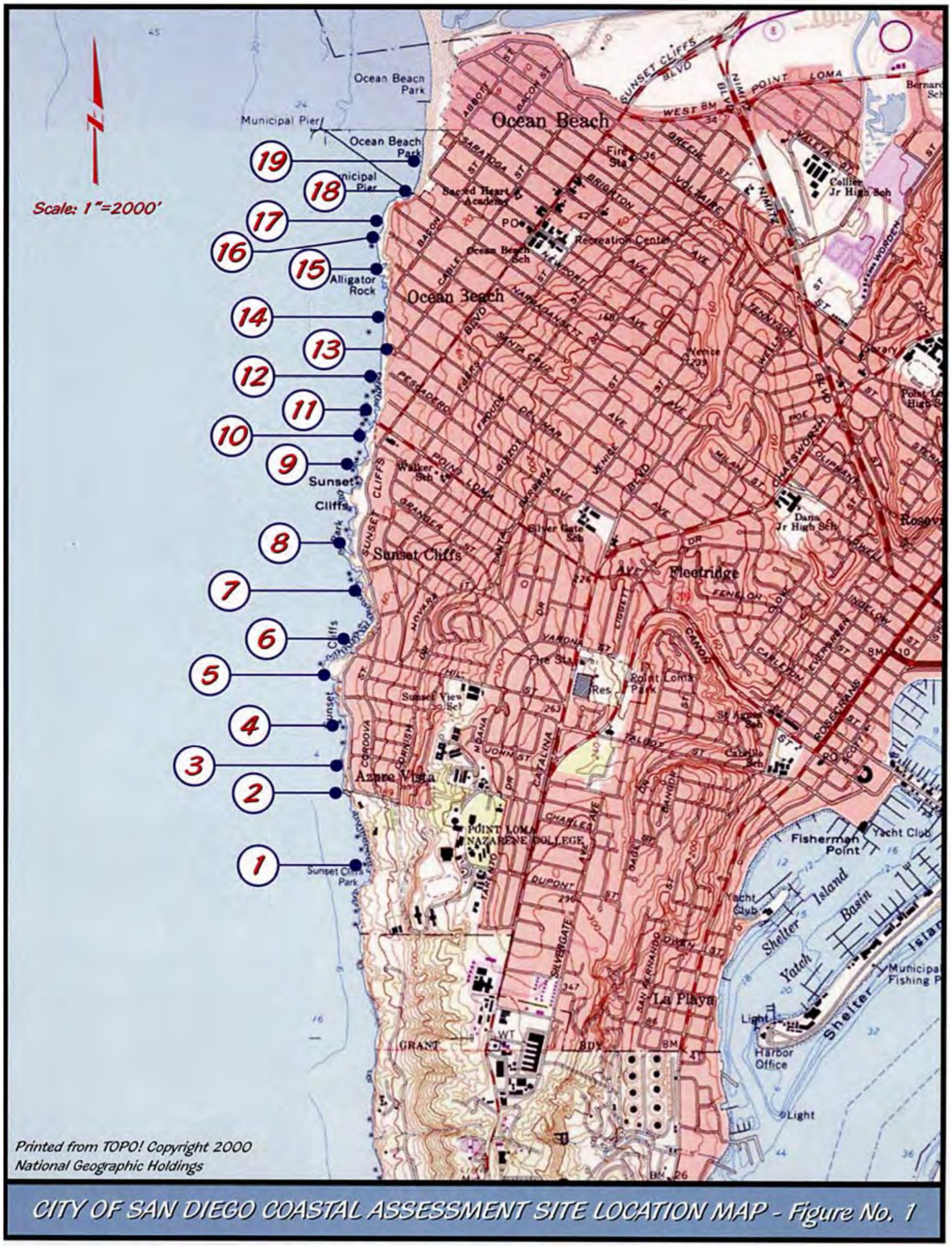


Figure 1-1. City of San Diego Coastal Assessment Site Location

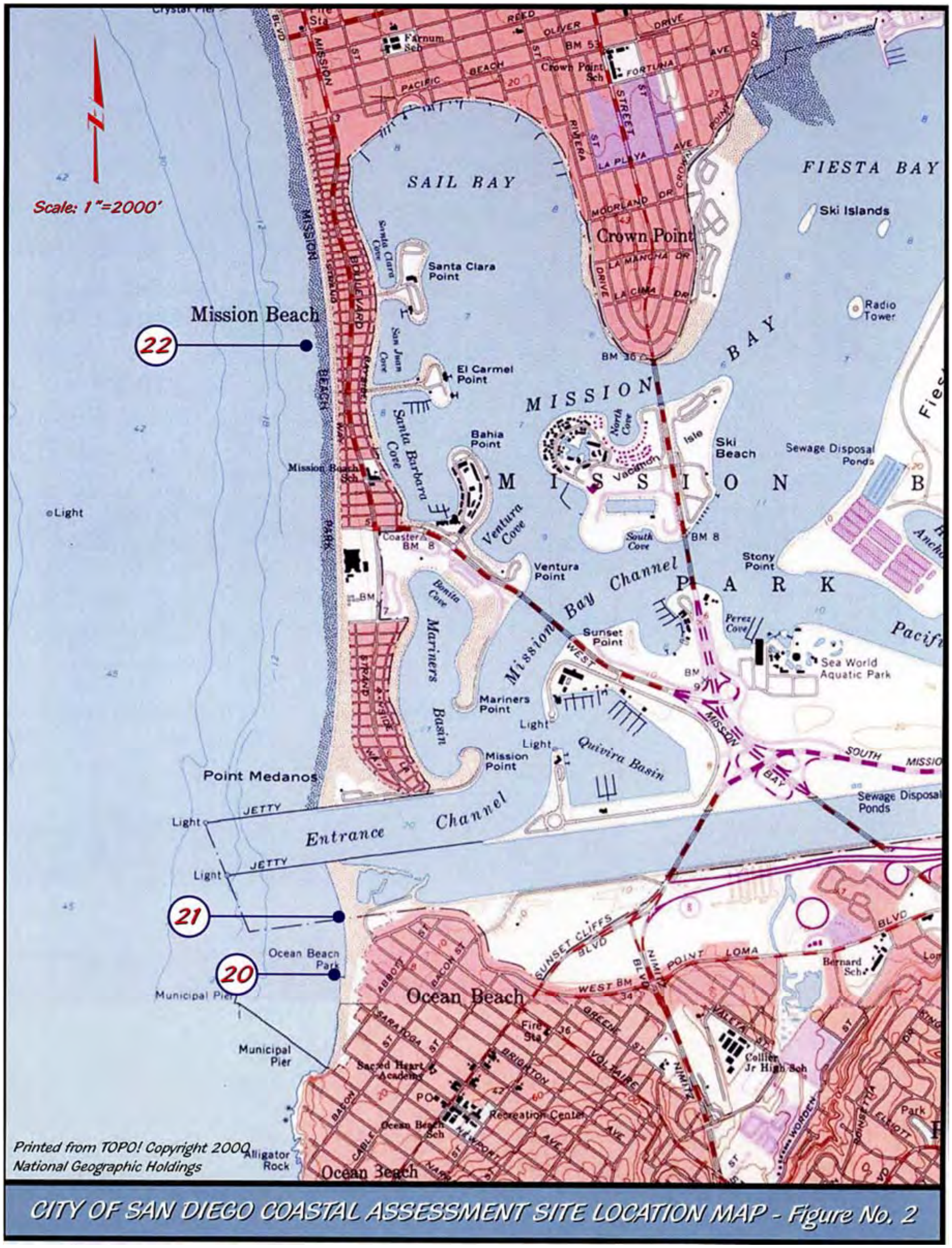


Figure 1-2. City of San Diego Coastal Assessment Site Location

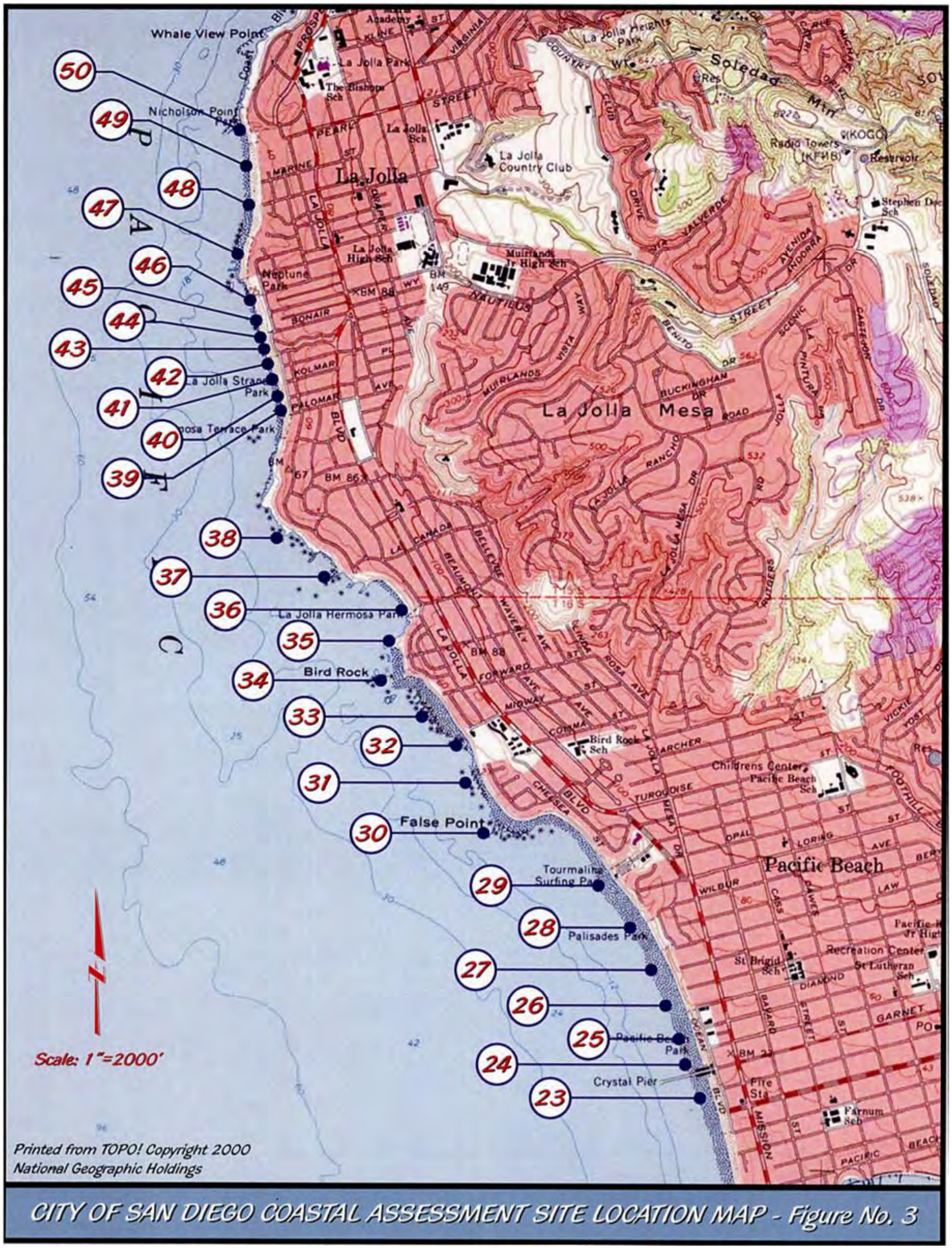


Figure 1-3. City of San Diego Coastal Assessment Site Location

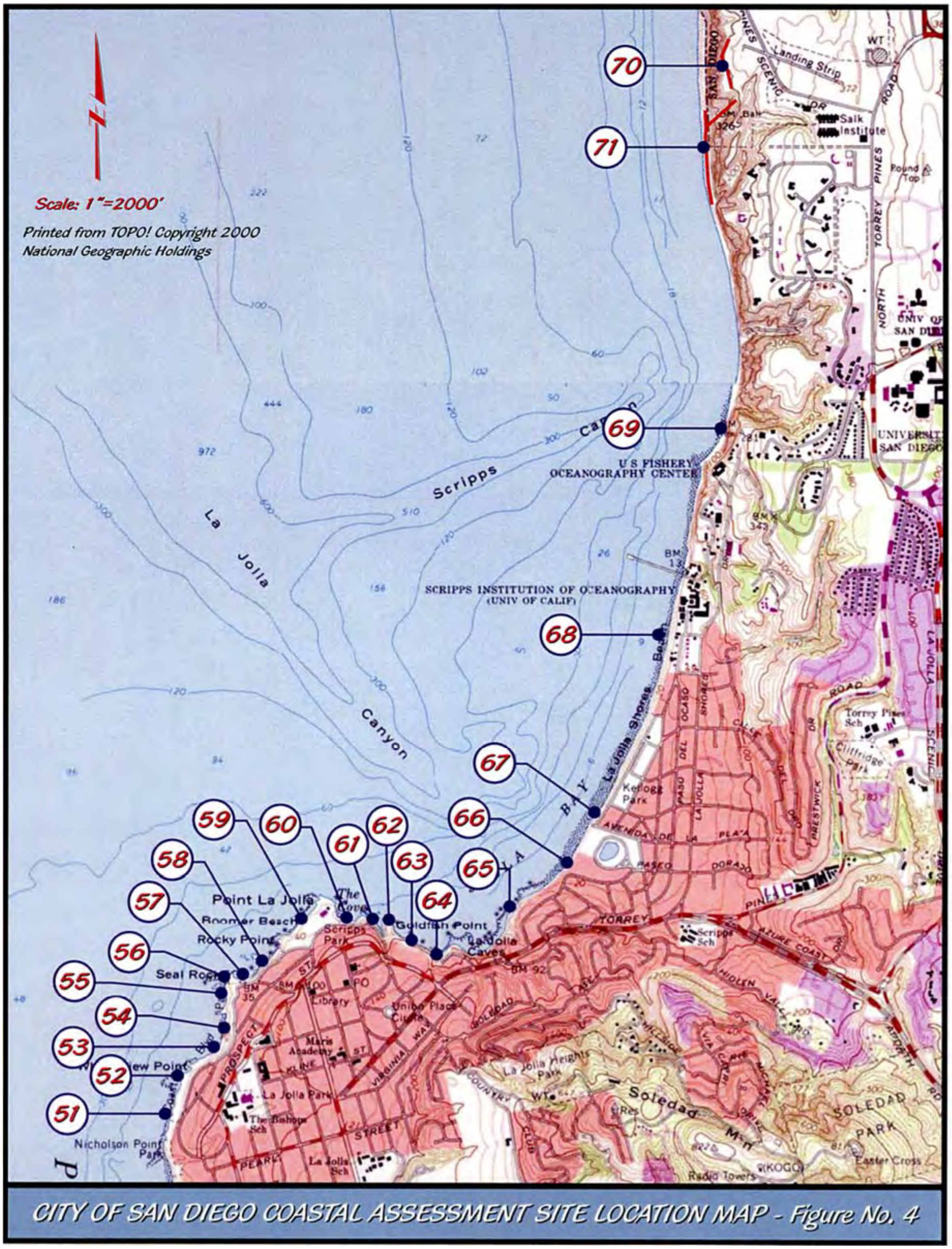


Figure 1-4. City of San Diego Coastal Assessment Site Location

Table A-2. Timeline for Coastal Erosion Photograph Comparison Assessment

Site Number	Date
Sites 1–22	July 9, 2018 (9 a.m.–2 p.m.) These sites started at the north edge of Sunset Cliffs Park just south of Ladera Street till the northern edge of Ocean Beach.
Sites 23–38	July 10, 2018 (9 a.m.–4 p.m.) These sites encompassed the south side of Pacific Beach up to Sun Gold Point. Many sites could not be accessed due to seasonal high tide.
Sites 39–51	July 11, 2018 (1 p.m.–5 p.m.) These sites were within the south side of Windansea Beach up to Nicholson Point. The sites had low cliff levels and were significantly easier to access than the previous day's sites.
Sites 51–57	August 14 These sites were within the south side of La Jolla leading up to La Jolla Cove
Sites 58–64	August 15 These sites started at La Jolla Cove leading up towards the end of the Coast Walk trail.
Sites 65–71	August 16 These sites consisted of the southern tip of La Jolla Shores up to Black's Beach.
Make Up Sites (Sites 22, 32, 33,34)	August 17th These sites consisted of Mission Beach and the coastline by Calumet Park.

Site 1

Site Number from 1993/2003 CEA document	1
Site Location	Sunset Cliffs Park
Priority Rating	Low
Picture number 1 from Site 1 from the 1993/2003 CEA document	

1993

2003

2018

2018 Observations:

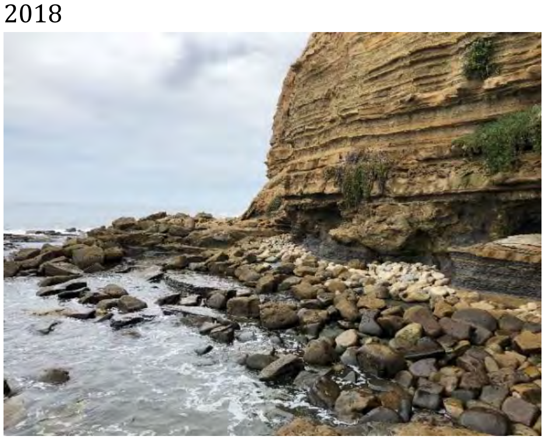
The private property access point is no longer accessible to the public due to construction projects around the site. The condition of the bluff suggests that minor subaerial erosion has taken place. Moreover, new pedestrian barrier railings have been added, perhaps to prevent public access through this path way.

2018 Summary Update:

- No major changes since 2003
- Area deemed a low risk in 2003 minimal subaerial erosion
- The photograph suggests no major potential pedestrian hazards

Site 2

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>2</td></tr>
<tr><td>Site Location</td><td>Ladera Street Access Stairway</td></tr>
<tr><td>Priority Rating</td><td>No Rating</td></tr>
<tr><td colspan="2">Picture number 1 from Site 2 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The 2018 photograph is not taken from the same vantage point as the 2003 photograph. Seasonal high tide prevented access to the site. The pedestrians access way contains area restrictive signage. However, the stair case is still accessed by surfers and pedestrians regardless of the signage. The proper representative photograph mimics the 1993/2003 CEA.

2018 Summary Update:
Pedestrians illegally cross to access the area. There seems to be a large sign that says "No pedestrian access" above a staircase
Once at the bottom the area contains slippery rocks to access the other sides of the beach.</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Site 3

Site Number from 1993/2003 CEA document	3
Site Location	Ladera Street to Carmelo Street
Priority Rating	Low

Picture number 1 from Site 3 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

The 2003 study indicated that the street drain was in “good condition.” The photograph suggests the drain has not changed much since 2003. The City appears to have added weight bags to prevent massive objects from blocking the drain. Thus, the photograph highlights that the drain continues to be in the same condition as it was in 2003.

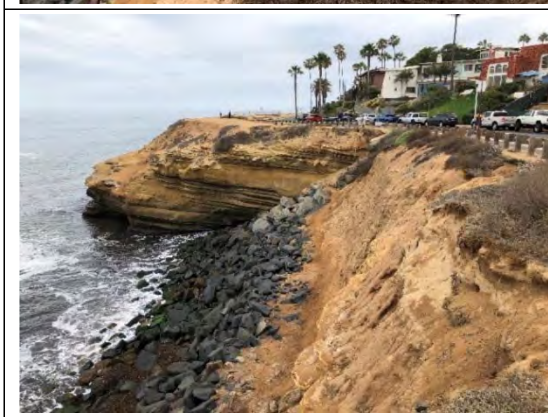
2018 Summary Update:

- No major changes to site since 2003
- Area deemed a low risk in 2003
- The photograph suggests no major potential pedestrian hazards

Site 4

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>4</td></tr>
<tr><td>Site Location</td><td>Carmelo Street to Monaco Street</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 1 from Site 4 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The bluff retreat looks like it has eroded by approximately a foot and a half. Furthermore, the cliff foothill trail, in the right side of the photograph, appears to be slightly steeper and narrower than in the 2003 photograph. The possible change in angle of the foothill trial is indicative of enhanced erosion.

2018 Summary Update:
• Marine and subaerial erosion appears to approach the street protection barrier</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 4 Photographs from 2018	
	The Gabion basket continues to remain in place and is located under a concrete apron drainage system
	100-foot-wide fill slope in between Carmelo Street and Monaco Street
	The erosion appears to be nearing the street protectors in between Carmelo Street and Monaco Street
	Additional vegetative cover since the last photographs were taken in 2003.

	The double-barrel CMP storm drain appears to have not changed. The reconstruction of the slope around the double-barrel CMP storm drain seems to have not changed much since 2003.

Site 5

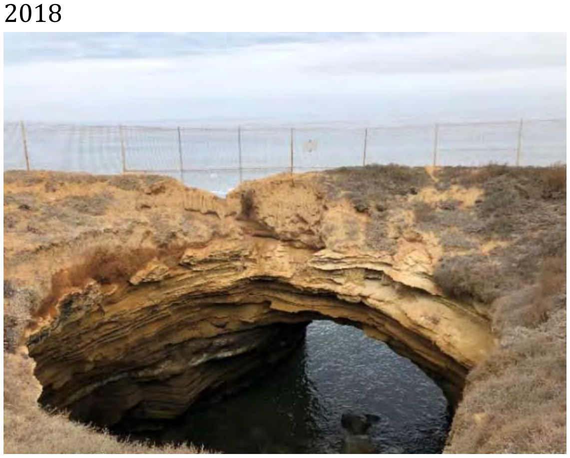
Site Number from 1993/2003 CEA document	5
Site Location	Monaco Street to Hill Street
Priority Rating	Low

Picture number 2 from Site 5 from the 1993/2003 CEA document

1993

2003

2018



2018 Observations:
In order to take a photograph of Site 5, the photographer had to stand behind a metal fence that has cordoned off the public from entering this part of the site. The high tide makes the bridge appear to be taller than before. However, with a closer look into the bridge, it seems the bottom of the bridge has additionally collapsed. The bridge base appears to have narrowed, and the bridge arch is higher. The photograph suggests that the conglomerate rocks collapsed underneath the bridge. Furthermore, the site looks to have lost a lot of its vegetation due to subaerial erosion.

2018 Summary Update:

- Major erosional changes
- Area deemed a low risk in 2003
- No pedestrian hazards as area is fenced off 4 feet from the erosion. The lack of effect on pedestrian livelihood is why the site received a low priority rating

Supplemental Site 5 Photograph from 2018	
	Twin 24-inch-diameter CMP storm drains for the street drainage from the Monaco Street-end seemingly continues to function. Many ride-share bikes appear to have been thrown down the cliffs.

Site 6

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>6</td></tr>
<tr><td>Site Location</td><td>Hill Street to Guizot Street</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 1 from Site 6 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
Under the left side of the pavement, the City appears to have made safety modifications to the surface; such as, the City appears to have added more rocks to the area to help stabilize the storm drain and the surrounding area. Moreover, there looks to be additional vegetation to combat the enhanced erosion. Since 2003 there appears to be further structural pavement collapse.

2018 Summary Update:
Erosion appears to approach the street protection barrier
Formation of new fractures along the bluff
Erosion interfering with pedestrian access ways
In 2003 the site was deemed a high risk</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 6 Photograph from 2018	
	The erosion appears to be approaching the pavement edge in between Hill and Guizot Street.

Site 7

Site Number from 1993/2003 CEA document	7
Site Location	Guizot Street to Froude Street
Priority Rating	High

Picture number 1 from Site 7 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

Based on the bluff retreat, additional vegetation installations, and new fissuring there appears to be more erosion over time. From 1993 to 2003 additional pavement structures and vegetation were added to prevent the bluff retreat. The top of the bluff consists predominantly of sandstone and conglomerate deposits. There appears to be continued fissuring of the base of the cliff. The changes in the toe of the Loma formation seem to display a slightly steeper slope angle in 2018. The 2018 photograph shows new vegetation around the guard rail and the ledge to help stabilize the bluff retreat. Between 2003 and 2018 the City added a stabilized pavement structure to prevent further erosion of the bluff encroaching toward the road barrier around the point where the civilian is seen standing in the 1993 photograph.

2018 Summary Update:

- Erosion appears to approach the street protection barrier
- Formation of new fractures along the bluff
- Erosion interfering with pedestrian access ways
- In 2003 the site was deemed a high risk

Supplemental Site 7 Photograph from 2018	
	The photograph suggests enhanced erosion along the bluff on Guizot Street.

Site 8

Site Number from 1993/2003 CEA document	8
Site Location	Froude Street to Osprey Street
Priority Rating	High

Picture number 3 from Site 8 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

The pavement path edge appears to have completely eroded away. The photograph suggests that additional vegetation has been added to the cliff. Furthermore, there appears to be additional collapsed sedimentary rocks on the bottom of the cliff. Through the process of erosion rocks may have weathered away and simply fallen to the base of the cliffs.

2018 Summary Update:

- Erosion appears to approach the street protection barrier
- Formation of new fractures along the bluff
- Erosion interfering with pedestrian access ways
- In 2003 the site was deemed a high risk

Supplemental Site 8 Photographs from 2018	
	There appear to be collapsed remnants from the upper face of the bluff that have fallen onto the Reinforced Concrete Pipe (RCP) project rocks.
	The coastline suggests that marine and subaerial erosion has taken place along the pavement path.
	The pavement path appears to have heavily eroded.
	Parts of the pavement edge looks like it has collapsed from the street to the bottom of the cliffs.

	It looks like additional pedestrian signage has been added to prevent pedestrians from walking on the old pavement area.
	The photograph was taken near the south end of the bluff-top surface and shows how the erosion appears to be approaching the road barrier and pedestrian warning sign.

Site 9A

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>9A</td></tr>
<tr><td>Site Location</td><td>Osprey Street to Adair Street (Spaulding Park)</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 1 from Site 9A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The city appears to have added a new signage to discourage pedestrians from walking on those parts of the bluff. However, pedestrians seem to ignore the sign and continue to walk freely on the edge of the cliff. It appears that erosion encroaches towards the parking barriers.

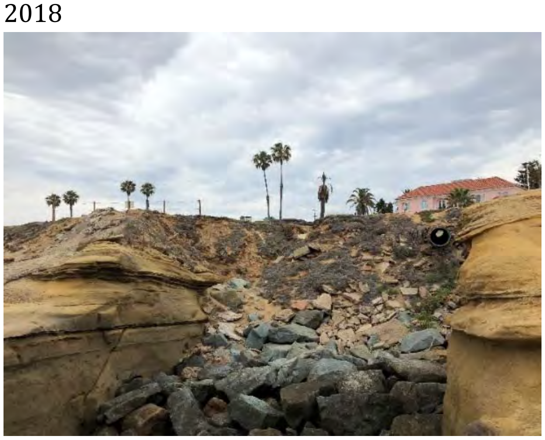
2018 Summary Update:
Improvements appear to have been made to the area
There seems to be a new “Stay Back” sign</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018

</td></tr>
</table>

Supplemental Site 9A Photographs from 2018	
	The earth wall used to be a popular climbing destination.
	The bluff erosion appears to encroach the vegetation area by Spaulding Park.

Site 9B

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>9B</td></tr>
<tr><td>Site Location</td><td>Osprey Street to Adair Street</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 3 from Site 9B from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
There appears to be new vegetation added to the area. The pipe seems to be in the same condition as in 2003. In the 1993/2003 CEA reports the pipe was described as being in “good condition.” The sedimentary rocks to the right of the photograph appear to have experienced minor marine and subaerial erosion. The 2018 photograph shows that the cliff has experienced minimal change.

2018 Summary Update:
No major changes since 2003
The photograph suggests no major potential pedestrian hazards
The previous CEA confirmed the pipe as “stabilized”</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 9B Photographs from 2018	
	A 14-inch curb inlet on Sunset Cliffs Boulevard appears to contain a crack on its wall foundation.
	The pipe from the opposite side appears to show no cracks around its foundation.
	The 30-inch RCP storm drain allows storm water and ground water discharge.

Site 10

Site Number from 1993/2003 CEA document	10
Site Location	Adair Street to Point Loma Avenue
Priority Rating	High

Picture number 1 from Site 10 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

The brick reinforcement directly west of the house seems to have eroded slightly. Moreover, there appears to be more sedimentary mass accumulating behind the debris fill, which, according to the 2003 CEA, was likely added “in the late 1950’s and 1960’s”. The base pavement that holds up the sedimentary rocks on the left end has slightly eroded over time. Some of the rocks from the edge of the bluff appear to have broken off. The bluff north of the residential building appears to display less vegetative cover than before and to have experienced subaerial erosion.

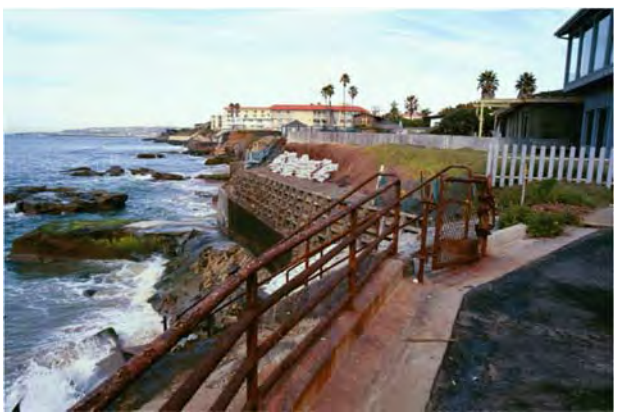
2018 Summary Update:

- Bluff to the north of the building appears to display less vegetative cover than before
- The bluff north of the residential area appears to experience subaerial erosion
- Sedimentary mass from the upper face of the bluff appears to have fallen to the bottom

Supplemental Site 10 Photograph from 2018	
	The photograph provides a different perspective of the bluff.

Site 11

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>11</td></tr>
<tr><td>Site Location</td><td>Point Loma Avenue to Bermuda Avenue</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 1 from Site 11A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
It appears that more reinforcement weight bags have been installed adjacent to the bluff. The bluff/vegetation area atop the concrete bricks appears to have been replaced by the weight bags. The greater number of weight bags suggests that there was a previous bluff collapse. Also, the public stairway seems to have experienced further enhanced erosion. Pedestrian warning signs have been added to prevent pedestrians from accessing the area the weight bags occupy.

2018 Summary Update:
Could not access the sea caves within the area
There is a steep cut off pedestrian access way that requires pedestrians to jump 1 meter down to access the caves and the beach end
The weight bags have completely replaced the bluff</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Site 12

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>12</td></tr>
<tr><td>Site Location</td><td>Bermuda Avenue to Pescadero Avenue</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 2 from Site 12 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The stairs display initial signs of rusting. The pedestrian access way has been cordoned off because the access point ladder (not pictured in this comparative analysis) appears to have eroded away. Moreover, there appear to be additional rocks added adjacent to the bluff. The City looks to have installed a new barrier to prevent pedestrians from entering the access point. The vegetation adjacent to the stairs has died off, which weakens the bluff structure around the staircase.
Could not access the base of the staircase
There is a steep cut off pedestrian access way that requires pedestrians to jump 1 meter down to access the caves and the beach end
Marine and subaerial erosion approaching the wooden fence</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Site 13

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>13</td></tr>
<tr><td>Site Location</td><td>Pescadero Avenue to Orchard Avenue</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 13 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The bed rocks adjacent to the pathway appear to have previously been at a higher point. The increase in the height of the entryway pathway has made it more difficult for pedestrians to enter this segment of the coastline. Relative to the 2003 photograph, the cobble-berm area appears to be filled with more large rocks near the entrance. Also, there are signs of corroding at the ledge of the entrance to the area.

2018 Summary Update:
High tide prevents pedestrians from venturing down to the beach
Change in height of pebbles from edge of the access way by the staircase creates a steep drop off</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 13 Photograph from 2018	
	The building near the coast is on stilts. The surrounding area seems to be eroding. The access way stair path prevents pedestrians from entering the beach.

Site 14

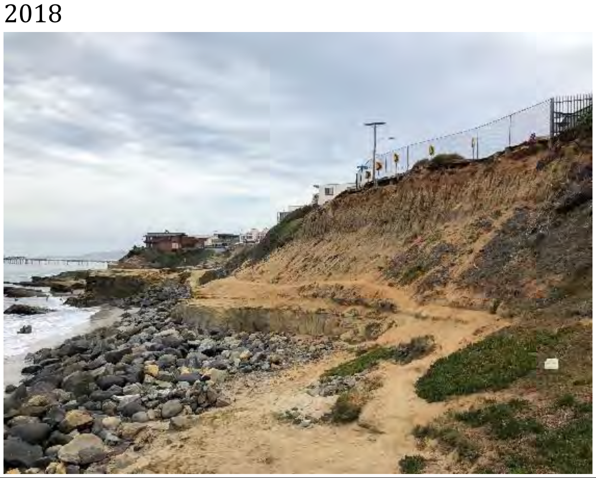
<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>14</td></tr>
<tr><td>Site Location</td><td>Orchard Avenue to Coronado Avenue</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 14 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The pathway in 2003 seems to be spread out and difficult to walk along. In the 2003 picture, the concrete pathway appears to have cracked and displaced in a non-linear fashion. Since the 2003 photograph, the concrete pavement appears to have been repositioned, so it is easier to walk across. On the base of the bluff, the pebbles appear to be mixed with sedimentary rocks due to enhanced erosion.

2018 Summary Update:
• No major changes to site since 2003
• Area deemed a low risk in 2003
• The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 14 Photographs from 2018	
	Photograph of the pedestrian stairway next to this concrete walkway by Orchard Avenue.
	Closer look at the re-organized walkway. Some of the pebbles to the right seem to be covered in sedimentary dirt, which suggests minor bluff collapse.
	The pedestrian walkway foundation shows no sign of cracks, and the railings show no signs of major corrosion.

	The pathway stairway and exit seem to be well stabilized. There seems to be slight rusting occurring on the pedestrian railway.

Site 15

Site Number from 1993/2003 CEA document	15
Site Location	Coronado Avenue Street to Santa Cruz Avenue
Priority Rating	Moderate
Picture number 1 from Site 15 from the 1993/2003 CEA document	
1993 	**2018 Observations:** The pedestrian foot trail is rather difficult to walk along. The slope morphology of the pathway is angled at around 30 degrees. Even though there appears to be a foot trail the geological composition of the trail breaks easily. The cliffside seems to be dusty, which provides poor traction and increases the potential for pedestrian accidents. Moreover, there appears to be more sedimentary composition atop the cobble-berm. **2018 Summary Update:** • The pedestrian access way is slippery and angled in a way that makes pedestrians prone to slip • Change in slope angle suggests more pressure at the base
2003 	
2018 	

Supplemental Site 15 Photographs from 2018	
	The access way appears to have been smoothed out for pedestrians to more easily access the trail.
	The brick bluff support structures to the right center side of the photograph appear to be sloped outward at the bottom more so than the two rows above.

Site 16

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>16</td></tr>
<tr><td>Site Location</td><td>Santa Cruz Avenue to Del Monte Avenue</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 2 from Site 16 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
Presently there appear to be more cracks on the bridge than there were in 2003. There appear to be cracks near the joints of the access way that pose a potential risk to pedestrians that walk along the access way. The pedestrians continue to create stress along the joint fractures. There seems to be enhanced erosion underneath the bridge, which could continue to harm the structural integrity of the bridge and stairs. There appears to be undercutting of the soft rock underneath the staircase foundation.

2018 Summary Update:
There seem to be cracks at the joints of the stairs
Marine and subaerial erosion encroaching underneath the cement pedestrian walkway</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 16 Photographs from 2018	
	The photograph suggests the Santa Cruz Avenue stairway experiences enhanced erosion along its base.
	Within the south end of Del Monte Street, the rock formation displays marine and subaerial erosion.

Site 17

Site Number from 1993/2003 CEA document	17
Site Location	Del Monte Avenue Street to Narragansett
Priority Rating	Low

Picture number 2 from Site 17 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

The surface of the apron seems to have partially eroded. There seem to be more cracks along the surface of the apron, but none seem detrimental to the structure. Moreover, the water pipe appears to have been buried in sedimentary material. The water pipe appears to have repositioned within the ground.

2018 Summary Update:

- No major changes to site since 2003
- Area deemed a low risk in 2003
- The photograph suggests no major potential pedestrian hazards

Supplemental Site 17 Photographs from 2018	
	The ledge along Del Monte Avenue seems to depict marine and subaerial erosion.
	To the right of the concrete apron there appears to be subaerial erosion.

Site 18

Site Number from 1993/2003 CEA document	18
Site Location	Narragansett Avenue to Newport Avenue
Priority Rating	Moderate
Picture number 2 from Site 18A from the 1993/2003 CEA document	
1993 	**2018 Observations:** It appears that the metal reinforcement rails no longer exist at the edge of the first stairway. The first stairway looks to have additionally eroded since 2003. The second stairway, on the left side of the photograph, seems to have eroded along the edge and contains cracks along the surface. Pedestrians heavily use both stairways to access small tide pools in the area. **2018 Summary Update:** • There appears to be slight marine erosion • The pedestrian staircase does not include a railway
2003 	
2018 	

Supplemental Site 18 Photographs from 2018	
	The railings and concrete structures in place all appear to have not changed since 2003. There seems to be no signs of cracks near the storm drain, and the staircase railings do not show any major signs of corrosion.
	The wall reinforcement and fence appear to have weathered. The base of the structures seems to be in place, but the wall seems to have heavily eroded.
	A photograph of a bluff face that is heavily covered with vegetation by the beach. The water barrier structures also appear to show no immediate signs of erosion.
	Pedestrians explore this dipped rock area. During high tide, the water creeps up very close to the pedestrian walkway on the other side of the barrier.

Site 19

Site Number from 1993/2003 CEA document	19
Site Location	Newport Avenue to Saratoga Avenue
Priority Rating	Low

Picture number 2 from Site 19 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

The area appears to be in similar condition to 2003 with no major erosional or coastal changes. In 2003 CEA the beach was described to be in “good” condition.

2018 Summary Update:

- No major changes to site since 2003
- Area deemed a low risk in 2003
- The photograph suggests no major potential pedestrian hazards

Site 20

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>20</td></tr>
<tr><td>Site Location</td><td>Saratoga Avenue to Brighton Avenue</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 2 from Site 20 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The 2003 CEA indicated that the street drain was in “good condition.” Thus, the photograph suggests that the beach seems to be in the same condition as it was in 2003.

2018 Summary Update:
No major changes to site since 2003
Area deemed a low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 20 Photograph from 2018	
	A view of the Ocean Beach coastline during seasonal high tide.

Site 21

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>21</td></tr>
<tr><td>Site Location</td><td>Brighton Avenue to San Diego River</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 2 from Site 21 from the 1993/2003 CEA document</td></tr>
<tr><td>1993

</td><td rowspan="3">2018 Observations:
The 2003 CEA indicates that the street drain was in “good condition.” The photograph suggests the beach has not changed much since 2003. Thus, the photograph suggests that the beach continues to be in the same condition it was in 2003.

2018 Summary Update:
No major changes to site since 2003
Area deemed a low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 21 Photograph from 2018	
	Dog Beach shows no signs of erosion, or threat to pedestrian livelihood.

Site 22

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>22</td></tr>
<tr><td>Site Location</td><td>Mission Beach Park</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 22 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The railings appear to have been redone since 2003. The rest of the site does not appear to display any immediate threat to pedestrian livelihood. Prior to this in 2003 there were signs of erosion on the bike pathway barriers.

2018 Summary Update:
The beach barriers appear to be fixed
There appears to be no major signs of erosion
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Site 23

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>23</td></tr>
<tr><td>Site Location</td><td>Thomas Avenue to Garnet Avenue and Crystal Pier</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 23 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
Fifteen years after the last assessment, the stairway appears to be in the same condition as before. There appear to be no major changes around the site. The 2003 CEA described the site as “good.”

2018 Summary Update:
No major changes to site since 2003
Area deemed a low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 23 Photograph from 2018	
	A photograph of the bluff to the left of the staircase access way to Pacific Beach. The bluff supports an infrastructure heavy area.

Site 24

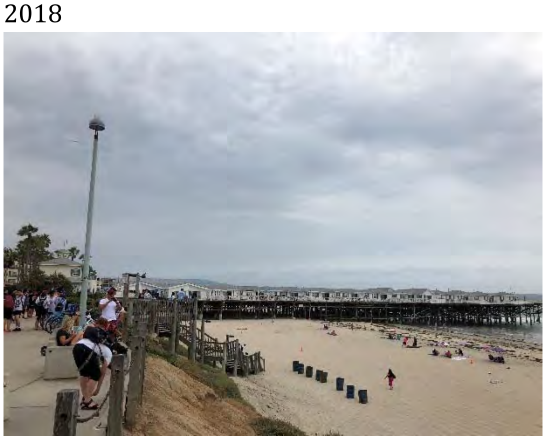
<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>24</td></tr>
<tr><td>Site Location</td><td>Garnet Avenue to Felspar Street</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 3 from Site 24 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The concrete infill bluffs seem to be relatively unchanged since 2003. The vegetation around the concrete infills seems to have grown since 2003. Overall the bluff is relatively in the same condition as it was in 2003. The 2003 CEA rated this segment of the site as “Low risk.”

2018 Summary Update:
• No major changes to site since 2003
• Area deemed a low risk in 2003
• The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 24 Photograph from 2018	
	The wooden reinforcement structures underneath Crystal Pier that support the Hotel stay above.

Site 25

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>25</td></tr>
<tr><td>Site Location</td><td>Felspar Street to Diamond Street</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 2 from Site 25 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The bluff that supports the staircase displays little to no change since 2003. There appear to be signs of marine and subaerial erosion. There is heavy pedestrian use of the area, and many concretes infills and wooden reinforcement barriers.

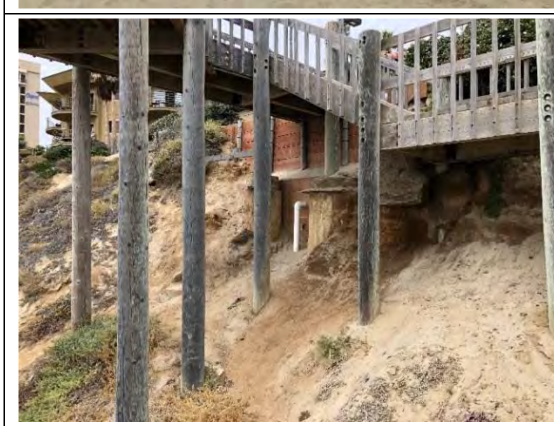
2018 Summary Update:
There appears to be marine and subaerial erosion
Heavy pedestrian usage
Wooden reinforcement barrier; concrete infills along the entire site</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 25 Photograph from 2018	
	A photograph of a bluff face adjacent to Crystal Pier that contains several reinforcement structures. The bluff face displays signs of marine and subaerial erosion.

Site 26

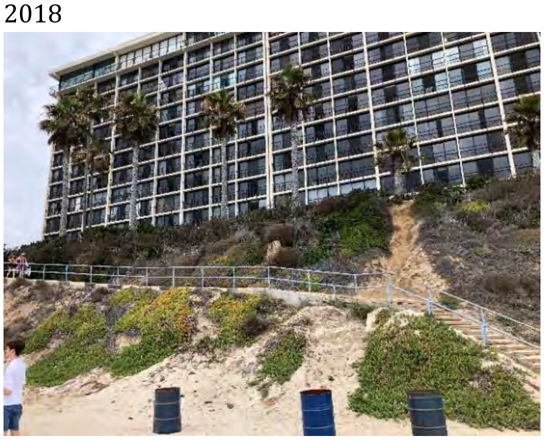
<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>26</td></tr>
<tr><td>Site Location</td><td>Diamond Street to Missouri Street</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 3 from Site 26 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
There appears to be further vegetation added to the bluff. The photographs show how the trees have grown since 2003. The reinforcement structures to the right of the photograph appear to have collapsed, which is a sign of enhanced erosion.

Conclusion:
• The staircase support structures are built within a bluff that shows signs of enhanced erosion
• Heavy pedestrian use within the area, which is why the site has a high priority rating</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 26 Photographs from 2018	
	The photograph suggests that the Diamond Street staircase and lookout structure are inserted within the bluff. The bluff appears to be experiencing enhanced erosion. The sedimentary material that makes up the bluff seems to be breaking in bunches and trickling down the slope.
	The photograph suggests signs of minor erosion near the bluff edge, but the walkway is a foot or two away from the pedestrian sidewalk.
	A few feet north of the Diamond Street stairway, the bluff suggests continued erosion. There seem to be many fractures along the bluff face. There also seems to be a variation in slope angle 3 feet below the top of the bluff.
	The support structures appear to be supported by the bluff. Continued erosion of the bluff may lead to the staircase completely collapsing.

Site 27

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>27</td></tr>
<tr><td>Site Location</td><td>Missouri Street to Law Street</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 4 from Site 27 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
There appear to be additional cracks in the 2018 staircase compared to the 2003 staircase. The cracks seem to be more focused around the joints of the stairs. Also, the photograph suggests enhanced erosion underneath the staircase, which further reduces the support by the stairs. The photograph suggests that there is new vegetation by the stair joints.

2018 Summary Update:
No major changes to site since 2003
Area deemed a low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 27 Photographs from 2018	
	The concrete storm drains and impact wall by Missouri Street show no signs of cracks.
	A photograph of the hotel that sits atop of the bluff by Missouri Street.
	A photograph of the vegetation along the bluff by the hotel.

	The pedestrian access way near the bluff contains many protective reinforcements to ensure pedestrians only enter the beach through the access ways created by the City.
	The north side of the pedestrian access way and reinforcement structures seem to be the same as in 2003. The road shows no sign of major fractures.
	Subaerial erosion adjacent to the pedestrian access way to the north end of Pacific Beach.

Site 28

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>28</td></tr>
<tr><td>Site Location</td><td>Law Street to Loring Street</td></tr>
<tr><td>Priority Ranking</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 2 from Site 28A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The slope access way appears to be relatively the same as it was in 2003. The 2003 CEA described the area as “safe access way.”

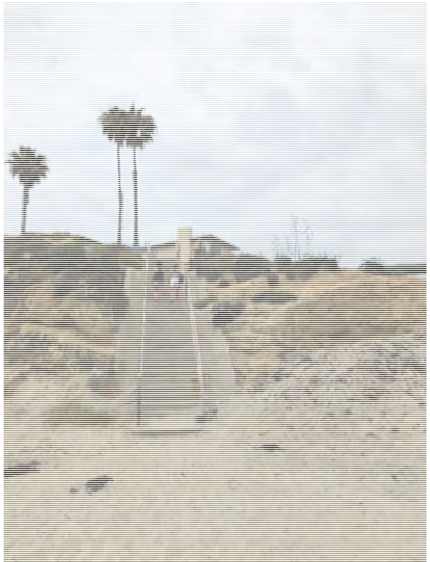
2018 Summary Update:
• No major changes to site since 2003
• Area deemed a low risk in 2003
• The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

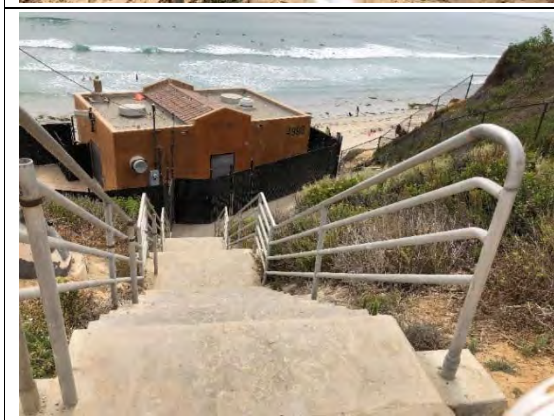
Supplemental Site 28 Photograph from 2018	
	This photograph from the right side of the pedestrian access way displays the bluff area with heavy vegetation and a pedestrian access way towards the north end of Pacific Beach.

Site 29

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>29</td></tr>
<tr><td>Site Location</td><td>Loring Street to Tourmaline Street</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 29A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
There appears to be new vegetation by the slope next to the stairs. Furthermore, the slope morphology in 2018 seems to be more diagonally directed. The sand berm installment looks to have filed out properly to create this change in slope morphology. The pipe appears to have slightly rusted over time. The short tree in the 2003 picture by the pipe hole appears to have been cut down or died in the 15-year time span.

2018 Summary Update:
There appear to be slight changes in the slope angle, but that is due to the sand berms naturally spreading out over time
There appears to be no major pedestrian hazards
The CMP storm drain shows no signs of cracks</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 29 Photographs from 2018	
	This photograph of the pedestrian stairway leading toward Loring Street contains a slightly rusty stairway railing.
	A photograph of Tourmaline Surf Park bluff. There appears to be heavy vegetation alongside the bluff.
	The pump station seems to have been further upgraded since 2003. The City appears to have added a new foundation structure around the pump station. There seems to be new fencing atop the foundation structure as well.

	A picture of the mid bluff pad, which is used for photographic vantage points of surfers.
	The bluff seems to be eroding slowly due to marine and subaerial erosion.
	Staircase to the pump station and another access point toward Tourmaline Surf Park.

Site 30

Site Number from 1993/2003 CEA document	30
Site Location	Tourmaline Surfing Park
Priority Rating	Low
Picture number 4 from Site 30 from the 1993/2003 CEA document	
1993 	**2018 Observations:** There appears to be more vegetation towards the north side of the bluffs by Tourmaline Surfing Park. It seems that an artificial cobble-berm at the beach crest has been constructed. In addition, it appears that seaward of the cobble-berm up to the base of the bluff, additional sand fill has been artificially added. The increase in cobble-berm makes it difficult for pedestrians to walk towards the Tourmaline Surfing Park. **2018 Summary Update:** • The cobble-berm at the beach has resulted in less water reaching the base of the bluffs by Tourmaline Surfing Park • There appear to be no imminent pedestrian hazards within the area
2003 	
2018 	

Supplemental Site 30 Photographs from 2018	
	A photograph of lifeguard tower 28 and a residential area atop the bluff. The pebbles have ensured lower amounts of foot traffic within the area.
	A bluff north of lifeguard tower 28. There appear to be signs of marine and subaerial erosion.
	A photograph of the entrance way parking lot by Tourmaline Surfing Park. The entrance way seems to have been redone; the City seems to have added cobble-berm and an artificial sand filler.
	The Bay Point formation sedimentary layer at the face of the bluff appears to have eroded due to marine and subaerial erosion.

	A photograph of the rocks on the La Jolla side of Tourmaline Surfer Park. There appears to be heavy vegetation. The rounded nature of the rocks on the face of the bluff suggest signs of weathering.

Site 31

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>31</td></tr>
<tr><td>Site Location</td><td>Calumet Pedestrian Access to Calumet Park</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 2 from Site 31 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The rocks in 2003 around the stairway appear to be larger and less rounded. It appears that the increase in tide height helped to round out and break apart the rocks. Additionally, the photograph suggests enhanced erosion toward the right side of the staircase. The stairway bottom seems to be more indented than before. The vegetation by the bluff on the right seems to have died out. The height difference between the staircase and the pebbles appears to be smaller than in 2003.

2018 Summary Update:
Once past the pedestrian access way it seems to be dangerous to walk along the slippery and mossy rocks
There appears to be erosion along the stretch
There are many “stay back from the cliffs” signs next to the pathway to the staircase</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 31 Photograph from 2018	
	A close-up image of the pedestrian access way. There seems to be slight rusting and cracks within the concrete of the stairs.

Site 32

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>32</td></tr>
<tr><td>Site Location</td><td>Calumet Park to Midway Street</td></tr>
<tr><td>Priority Rating</td><td>No Rating</td></tr>
<tr><td colspan="2">Picture number 1 from Site 32 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The picture suggests the pedestrian access way slope is incredibly narrow. The trail appears to be wet and muddy, which may lead to pedestrians slipping. The bottom part of the access way is shaped as stairs. The bottom part seems to be incredibly slippery, and each human-made stair is small. Due to unsafe and wet conditions ICF could not access the base of the site.

2018 Summary Update:
The pedestrian access way appears to be incredibly slippery and narrow
In the pathway along the beach there appear to be many mossy rocks and well-rounded large rocks, which makes it hard to walk across the site</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 32 Photograph from 2018	
	A photograph of a residential backyard wall that seems to be surrounded by an eroding surface.

Site 33

Site Number from 1993/2003 CEA document	33
Site Location	Midway Street to Forward Street
Priority Rating	High

Picture number 1 from Site 33 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

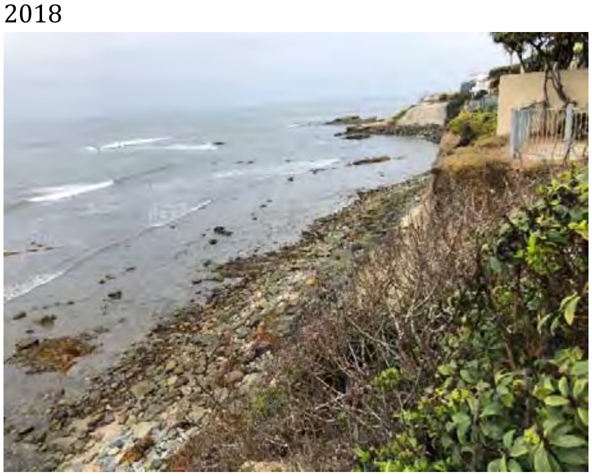
The 2018 photograph was not taken from the same vantage point as the 2003 photograph due to the seasonal high tide combined with the unsafe pedestrian access ways. The site could not be accessed in a safe manner as the pedestrian pathway was either too wet or too slippery. This inevitably leads to pedestrians walking along the slippery and mossy rocks, which could lead to potential injuries and liabilities. A photograph of the site was taken from atop the bluff in 2018.

2018 Summary Update:

- Could not access the pedestrian pathway due to hazardous conditions for reaching the representative photograph location
- Many residential areas atop the bluff that are combating bluff erosion with wooden reinforcements

Site 34

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>34</td></tr>
<tr><td>Site Location</td><td>Forward Street Street-End Improvements</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 1 from Site 34 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The 2018 photograph was not taken from the same vantage point as the 2003 photograph due to the seasonal high tide combined with the unsafe pedestrian access ways. The site could not be accessed in a safe manner as the pedestrian pathway was either too wet or slippery. This inevitably leads to pedestrians walking along the slippery and mossy rocks, which could lead to potential injuries and liabilities. A photograph of the site was taken from atop the bluff in 2018.

2018 Summary Update:
Could not access the pedestrian pathway due to hazardous conditions for reaching the representative photograph location
Many residential areas atop the bluff that are combating bluff erosion with wooden reinforcements</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Site 35

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>35</td></tr>
<tr><td>Site Location</td><td>Bird Rock Avenue to La Jolla Hermosa Park</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 35 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The staircase pedestrian access way appears to have been completely redone. The new stairway appears to have higher railings that protect pedestrians from the high tide. The new staircase is made from pure concrete which protects pedestrians from the water. Additionally, the vegetation seems to have been cut down completely. Also, the railing on the top of the access way has been reinforced, and wood has been replaced with PVC.

2018 Summary Update:
Major changes made to the staircase to raise the height of the railings, to replace PVC with concrete
There appears to be no signs of major bluff erosion</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Site 36

Site Number from 1993/2003 CEA document	36
Site Location	La Jolla Hermosa Park to Sun Gold Point
Priority Rating	Low

Picture number 2 from Site 36 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

The 2003 photograph suggests that the staircase used to be an access point towards the coast. The same staircase has been completely cut off to prevent pedestrians from accessing this path. The access way has been completely fenced off. The removal of the staircase has resulted in lower foot traffic at this point of the coast. The 2003 CEA described the park to be in “excellent condition.”

2018 Summary Update:

- The City has effectively cordoned off the pedestrian access way to the ocean
- The 2003 CEA described the area to be in “excellent condition”

Supplemental Site 36 Photograph from 2018	
	The staircase at La Jolla Hermosa Park, a popular and peaceful vantage points for locals to view the coast. The stairs in the photograph appear to be evenly spaced and show no major signs of cracks.

Site 37

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>37</td></tr>
<tr><td>Site Location</td><td>Sun Gold Point to Cortez Place</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 1 from Site 37 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The pedestrian access way toward the beach looks to be experiencing enhanced erosion. There seems to be corrosion along the PVC pipe staircase railing. The vertical side rails of the staircase look to be rusting away. The staircase side barrier protection displays small cracks. The rock formation near the staircase appears to be slowly eroding away.

2018 Summary Update:
• The access way down to the site appears to have a new railing since 2003
• The surrounding area is still subject to marine and subaerial erosion
• There seems to be corrosion on the edge of the staircase</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 37 Photograph from 2018	
	A closer look of the vertical side rails of the staircase, which seem to display initial signs of corrosion.

Site 38

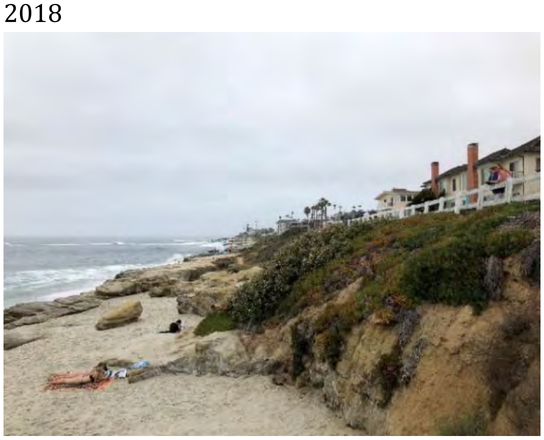
<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>38</td></tr>
<tr><td>Site Location</td><td>Cortez Place</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 1 from Site 38A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The marine erosion seems to have affected the headland of the north wall. There appear to be cracks along the sea wall. The coloration of the wall seems to be the same as it was in 2003. There appears to be slightly less vegetation along the bluff.

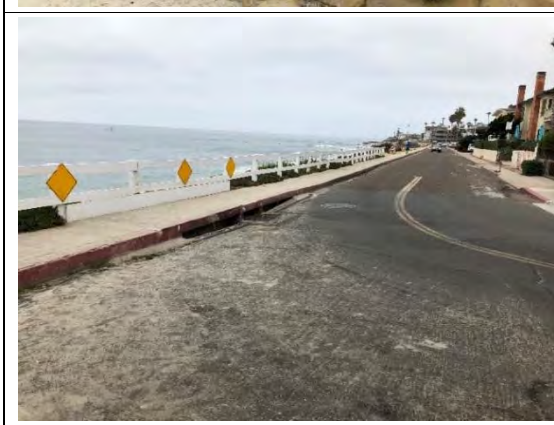
2018 Summary Update:
There appears to be marine and subaerial erosion
The photograph suggests the staircase railing is corroding</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 38 Photograph from 2018	
	A picture of the Cortez Place access way. Many residential houses surround the area and contain their own private access ways toward coast.

Site 39

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>39</td></tr>
<tr><td>Site Location</td><td>Palomar Avenue at Rosemont Street</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 39A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The photograph suggests a minor amount of marine erosion has occurred in the last 15 years. The pedestrian fences atop the bluff seem to be the same as in 2003. In the 2003 report the fences were described as being in “good” condition.

2018 Summary Update:
No major changes to site since 2003
Area deemed a low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 39 Photographs from 2018	
	A pedestrian staircase on Palomar Avenue that shows no signs of cracks.
	A photograph of the bluff near the south side of Windansea Beach. The sand filler layer protects the bluffs from water exposure.
	There seems to be additional wooden reinforcements structures. The photograph suggests minimal marine and subaerial erosion at the center of the picture.
	The street side view of Windansea Beach displaying the street drain and the white fence barrier structures.

	Another angle of the pedestrian fence and Rosemont Street next to Windansea Beach.
	A photograph of the edge of the white fence and entrance way foot trail to the beach alongside the white fence barrier.
	Another angle of the bluff showing one of the foot trails pedestrians can use.
	Close-up of one of the pedestrian access way foot trails on Palomar Avenue.

	The continuation of the pedestrian fence atop the bluff. The vegetation appears to flourish within this segment of the beach.
	The beach contains many local foot trails to access the beach. The beach appears to be 3-feet away from the edge of the bluff.

Site 40

Site Number from 1993/2003 CEA document	40
Site Location	Rosemont Street to Kolmar Street
Priority Rating	Low

Picture number 1 from Site 40B from the 1993/2003 CEA document

1993

2003

2018

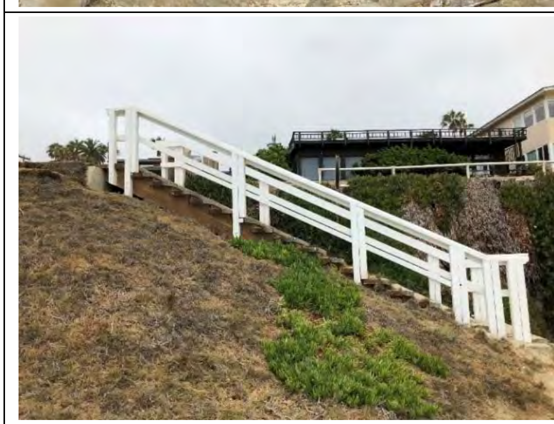
2018 Observations:

Vegetation overhanging the wall now nearly covers all the graffiti shown in earlier photographs. The plaster on the white wall seems to be pealing apart, and naturally eroding away. There appears to be a new pedestrian access way that was recently added to the site (see left side of photograph). The bluff to the right of the wall looks like it has slightly eroded since 2003. There used to be vegetation on the bluff to the right. Currently, sediment only covers the bluff to the right.

2018 Summary Update:

- No major changes to site since 2003
- Area deemed a low risk in 2003
- The photograph suggests no major potential pedestrian hazards

Supplemental Site 40 Photographs from 2018	
	Pedestrians at Windansea Beach sit on the slate rocks and create additional stress on the bluffs adjacent to the beach.
	A photograph of Palomar Avenue vegetation with a pump station in the distance.
	The white staircase provides a passageway down the bluff. The bluff edge shows signs of marine and subaerial erosion.
	A close-up view of the vegetation that overhangs the graffiti plaster wall near Palomar Avenue.

	Heavy vegetation surrounds the residential condominiums.
	A photograph of one of the pedestrian foothill trail access ways. The path does not contain many footmarks.
	The middle section of the graffiti mural near Palomar Avenue. The pedestrian protection barrier seems to show no signs of fracturing, or change in shape, and the overhanging vegetation covers the slightly eroded paint.
	The white pedestrian staircase looks relatively new and is frequently used by pedestrians to access the beach.

	A zoomed in photograph of the foothill displays the slight erosion potentially caused by pedestrian foot traffic.

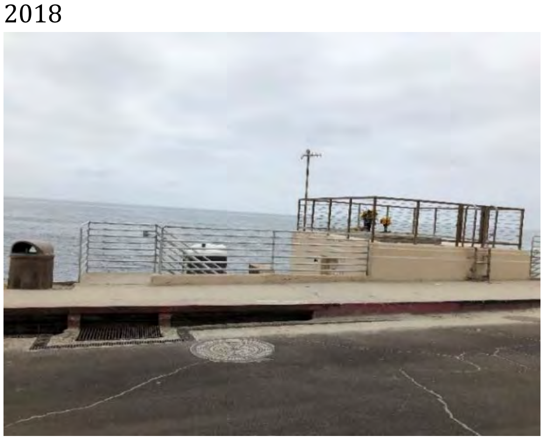
Site 41

Site Number from 1993/2003 CEA document	41
Site Location	Kolmar Street to Gravilla Street
Priority Rating	Low
Picture number 2 from Site 41E from the 1993/2003 CEA document	

1993

2003

2018

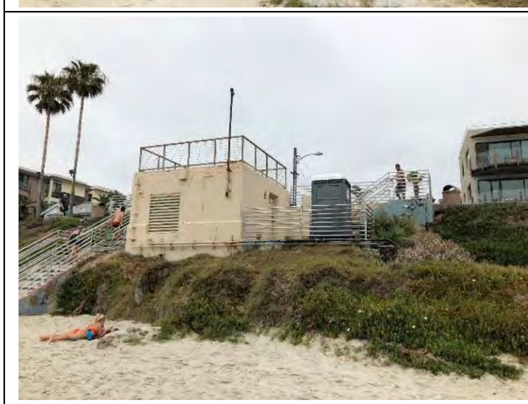


2018 Observations:

The storm drain pipe in 2003 appears to have been damaged and heavily eroded. It seems the City has replaced the non-rusting drain pipe street cover. Moreover, the photograph suggests that the drain area concrete was redone. The pump station looks like it has been repainted and upgraded since 2003. Additionally, the pedestrian protection barrier seems to have been upgraded as well. There appear to be more railing rungs in the 2018 railings than in the 2003 railing.

2018 Summary Update:

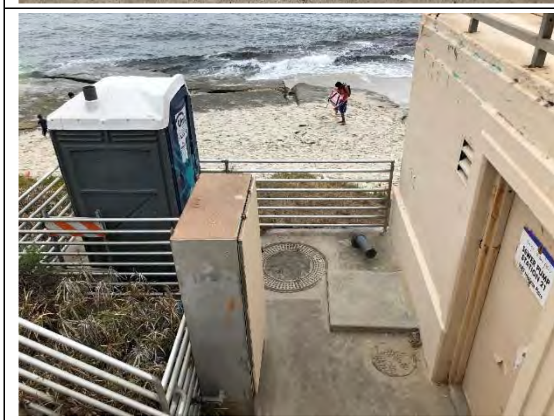
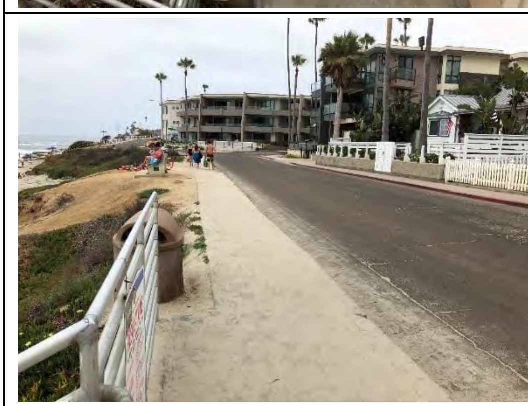
- No major changes to site since 2003
- The street drain appears to be upgraded
- Area deemed a low risk in 2003
- The photograph suggests no major potential pedestrian hazards

Supplemental Site 41 Photographs from 2018	
	The bluff by Kolmar Street looks like it is heavily covered by vegetation.
	Another wall with overhanging vegetation and graffiti that is adjacent to the previous graffiti wall.
	The right side of the graffiti wall seems to show slight signs of marine and subaerial erosion.
	A photograph of pump station 67 near Gravilla Street with what appears to be a newly reinforced stair railing.

Site 42

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>42</td></tr>
<tr><td>Site Location</td><td>Gravilla Street to Playa del Sur</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 42A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The stairway access seems to show no signs of immediate corrosion. The safety rails appear to have been redone. There were relatively little to no changes since 2003. The 2003 CEA determined this part of the site as “low risk.”

2018 Summary Update:
No major changes to site since 2003
The staircase appears to have been redone since 2003
Area deemed a low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 42 Photographs from 2018	
	A photograph of pump station 67, which is supported atop a bluff that is filled with vegetation.
	The stairs by Gravilla Street that show no signs of immediate erosion.
	An look at the walkway toward pump station 67, with an access way.
	A look at the pedestrian walkway next to Windansea Beach. There appears to be erosion along the bluff.

Site 43

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>43</td></tr>
<tr><td>Site Location</td><td>Playa Del Sur To Playa Del Norte</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 2 from Site 43B from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The site used to contain significantly less vegetation supporting the bluff. Currently there appears to be a significant amount of vegetation surrounding the reinforcement structure.

2018 Summary Update:
No major changes to site since 2003
Area deemed a low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 43 Photographs from 2018	
	A foothill trial access way near Gravilla Street. The photograph suggests the surrounding area contains heavy vegetation.
	The pavement structure that supports the road shows no signs of cracks. The photograph is of a storm drain for ground water and rain water.
	A storm drain pipe on Gravilla Street that appears to have interiorly collapsed.
	The erosion appears to be a sizeable distance from the foundation of the bench. There does not appear to be any immediate threat to the areas surrounding the bluff.

Site 44

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>44</td></tr>
<tr><td>Site Location</td><td>Playa Del Norte to Bonair Street</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 44B from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The CMP storm drain pipe appears to be in the same condition it was in 2003. There appears to be new vegetation planted within the area since 2003. Moreover, the new shape configurations of the channel suggest that erosion has taken place. The City seems to have smoothed out the pathway across the channel to make it easier for pedestrians to cross over from one part of the beach to the next. The smoothening and slight lowering of the height of the channel makes it easier for pedestrians to access the northern side of Windansea Beach.

2018 Summary Update:
No major changes to site since 2003
Area deemed a low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 44 Photographs from 2018	
	The minor road cracks in the Bonair Street pedestrian walkway suggest minor erosion and weakening of the road structure.
	A pedestrian foothill trail leading towards the Northern end of Windansea Beach. The foothill trail is relatively flat and obvious.
	A closer look at the foothill trail entrance displays signs of minor erosion. The pedestrian streetway is slightly unsupported by the bluff but is still safe to access and walk across.
	The beach hut structure on the beach appears to have been redone since 2003

Site 45

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>45</td></tr>
<tr><td>Site Location</td><td>Bonair Street to Nautilus Street</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 3 from Site 45B from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
This access point is directly adjacent to the parking lot. There appear to be many footmarks on the slope, which suggests heavy pedestrian usage. There appear to be additional gravel fillers implanted within the downward slope. There seems to be a natural foothill trail developing since 2003. The path continues to erode, but the potential reinforcements and filler structures have helped slow the rate of erosion. The channels that appear to be forming along the bluff suggest enhanced erosion.

2018 Summary Update:
The bluff appears to be experiencing marine and subaerial erosion
The erosion approaches the pedestrian access way</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 45 Photographs from 2018	
	The foothill pedestrian access trail contains relatively heavy foot traffic because it is the closest access way to the beach from the Windansea Beach parking lot.
	The large number of footmarks suggest the pedestrian foothill access trail is heavily used. Slight erosion channels appear to be forming on the bluff face.

Site 46

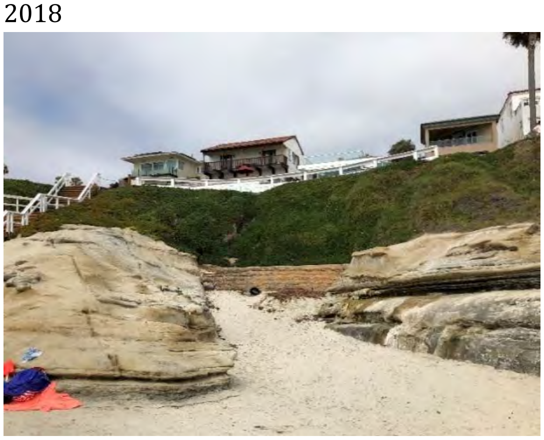
Site Number from 1993/2003 CEA document	46
Site Location	Nautilus Street to Westbourne Street
Priority Rating	Low

Picture number 1 from Site 46B from the 1993/2003 CEA document

1993

2003

2018



2018 Observations:

The photograph suggests that since 2003 the sand level has risen. There appears to be an eroded channel atop the drain hole in the 2003 photograph. By 2018 the City seems to have added new vegetation to the previously eroded channel. Also, it appears that the CMP pipe interiorly collapsed. Furthermore, the sand appears to be slightly higher than in 2003. The sand seems to be on higher parts of the bluff than in the 2003 photograph.

2018 Summary Update:

- Sand level rises to the edge of the storm drain
- No major changes to site since 2003
- Area deemed a low risk in 2003
- The photograph suggests no major potential pedestrian hazards

Supplemental Site 46 Photographs from 2018	
	A photograph of the staircase access way on Nautilus Street. The photograph suggests there is heavy vegetation within the area. The photograph also suggests that the staircases have been redone recently.
	There appear to be signs of tide increase. Moreover, the sand looks to be at a higher point than in 2003. The sand height seems to be creeping up towards the street level height, suggesting higher tides and a slight increase in sea level.
	The pedestrian access way fence seems to be well reinforced.
	The photograph suggests the erosion has approached the foundation base of the bench.

	The sediment formation shows signs of marine and subaerial erosion.
	The sand is not aligned with the base of the stairway. The staircase appears to be evenly spread out and aligned properly.
	The staircase railing seems relatively new, and well reinforced.
	The staircase railings appear to be newly painted.

	There appears to be a fracture forming within the bluff. The ground water and ocean water naturally channel in and out of the fracture. This could cause further weathering of the fracture and potentially lead to further bluff structural failure.
	The photograph suggests that the slope morphology of the bluff is at a steep angle, and the erosion is approaching the street pathway. The foothill trail access way appears to be unused, which will help to keep the bluff as is.
	The residential backyard is at a moderately lower height than the other buildings along the coastline.

Site 47

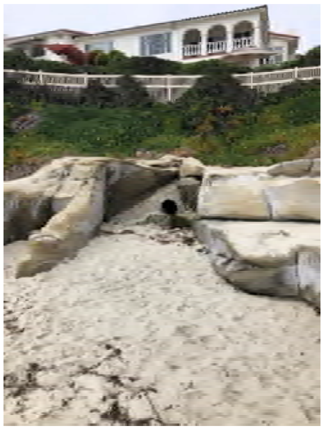
<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>47</td></tr>
<tr><td>Site Location</td><td>West of Vista De La Playa</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 47C from the 1993/2003 CEA document</td></tr>
<tr><td>1993

</td><td rowspan="3">2018 Observations:
The storm pipe drain has been closed off with a barrier. The barrier appears to still enable water to exit from the drain but prevents the entry or exit of large objects through the drain. Aside from the drain cover the area appears to be relatively the same as in 2003.

2018 Summary Update:
No major changes to site since 2003
Area deemed as low risk in 2003
The photograph suggests no major potential pedestrian hazards</td></tr>
<tr><td>2003

</td></tr>
<tr><td>2018

</td></tr>
</table>

Supplemental Site 47 Photographs from 2018	
	A CMP storm drain near Vista De La Playa street.
	The area around the drain appears to have slightly eroded away; however, there seems to be no blockage in the discharge flow.
	The photograph suggests the formation of new fractures on the face of the bluff. The cracks can potentially be attributed to the residential areas nearby.

	The City appears to have added reinforcement rocks to the bluff.
	The stair access way seems to have a deep drop off to the beach after the last step. Pedestrians need to jump to access the beach. The walls show minor signs of marine and subaerial erosion.
	The photograph suggests the staircase to the beach was recently repaired. Nevertheless, the erosion encroaching the stairs might be cause for concern.

Site 48

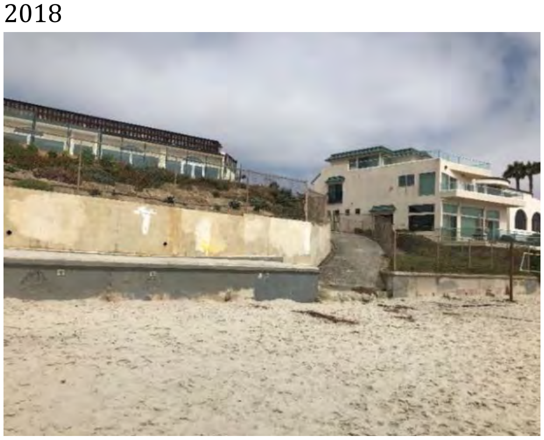
<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>48</td></tr>
<tr><td>Site Location</td><td>Sea Lane Street End</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 2 from Site 48A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
It appears the City has smoothed out the pedestrian street access way. The foothill trail access provides a route for pedestrians to enter the beach, whereas the previous structure posed a risk for pedestrians attempting to illegally access the beach. The flattening of the access way has resulted in a safer passageway for pedestrians to access the beach.

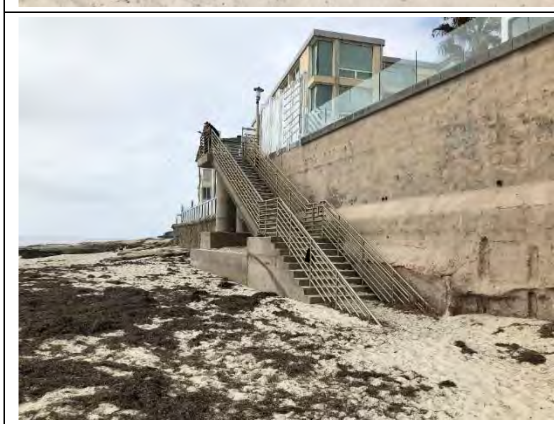
2018 Summary Update:
The pedestrian access way to the beach seems to be a little steep
The access way appears to be narrow path</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 48 Photograph from 2018	
	A closer look of the side access foothill path, which appears to be heavily used. Note the signs of erosion on the area to the left of the pathway.

Site 49

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>49</td></tr>
<tr><td>Site Location</td><td>Marine Street End</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 49C from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The ramp access way appears to be relatively the same with little to no change since 2003. The 2003 CEA described the vehicular access ramp to be in “good” condition.

2018 Summary Update:
2003 CEA labeled the ramp to be in “good” condition
No apparent pedestrian hazards within the photograph
Area deemed as low risk in 2003</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 49 Photographs from 2018	
	The private property wall, which contains no major cracks.
	A closer look at the staircase; there appears to be a tiny fracture by the drain hole for groundwater.
	The increased sand level next to the storm drain pipe poses a cause for concern.
	The staircase 300 feet north of the previous staircase provides an access path for the pedestrians in the residential areas.

	A side view of the pedestrian staircase. The pedestrian railways show no sign of rusting.
	The pedestrian staircase seems moderately new.

Site 50

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>50</td></tr>
<tr><td>Site Location</td><td>West of Coast Boulevard near Ravina Street</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 2 from Site 50A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The sand level has risen since 2003. The rocks next to the staircase appear to have eroded away. In addition, there are new structures atop the storm drain pipe. The photograph suggests the smoothening of the access trail. The CEA from 2003 labeled the drainpipe to be in “reasonable” condition.

2018 Summary Update:
2003 CEA labeled the drainpipe to be in “reasonable” condition
No apparent pedestrian hazards within the photograph
Area deemed as low risk in 2003</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 50 Photograph from 2018	
	An additional drain adjacent to the residential area on the south end of La Jolla. This part of the coastline is predominantly accessed through private gates and entryways. The area is popular for its tide pools and marine life.

Site 51

Site Number from 1993/2003 CEA document	51
Site Location	Coast Boulevard
Priority Rating	Low

Picture number 1 from Site 51C from the 1993/2003 CEA document

1993

2003

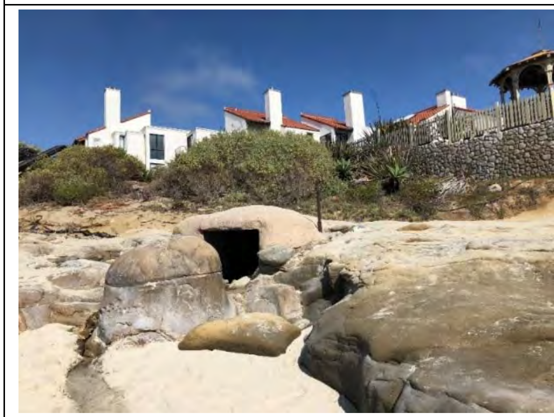
2018

2018 Observations:

The photograph suggests that the fracture in front of the pedestrian lookout has been smoothed out and filled since 2003. The erosion encroaches the edge of the foundation on which the seating area rests. In addition, the slope morphology seems to be more steeply angled.

2018 Summary Update:

- 2003 CEA labeled the viewpoint to be in “reasonable” condition
- No apparent pedestrian hazards within the photograph
- Area deemed as low risk in 2003

Supplemental Site 51 Photographs from 2018	
	A picture of the staircase that leads to the La Jolla Tide Pools. The staircase shows no signs of corrosion or erosion.
	A storm drain outlet and landscaped slope that are both adjacent to pump station 24.
	A pedestrian bench alongside the La Jolla Tide Pools area.
	Storm drain adjacent to the pump station.

	Coast Boulevard street adjacent to the La Jolla Tide Pools shows no major signs of erosion or pedestrian hazards.

Site 52

Site Number from 1993/2003 CEA document	52
Site Location	Coast Boulevard Park
Priority Rating	Low
Picture number 1 from Site 52A from the 1993/2003 CEA document	
1993 	**2018 Observations:** The stairs have shown little to no change since 2003. The CEA labeled the site to be in "good" condition. The stairs appear to be evenly spread out, and the railings seem to show no sign of rusting. **2018 Summary Update:** • 2003 CEA labeled the staircase to be in "good" condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
2003 	
2018 	

<table>
<tr><th colspan="2">Supplemental Site 52 Photographs from 2018</th></tr>
<tr><td></td><td>Coast Boulevard Park appears to have no major signs of substantial erosion.</td></tr>
<tr><td></td><td>A closer look at the stairs south of Coast Boulevard Park. The stair-to-stair height seems to be slightly different for each riser.</td></tr>
</table>

Site 53

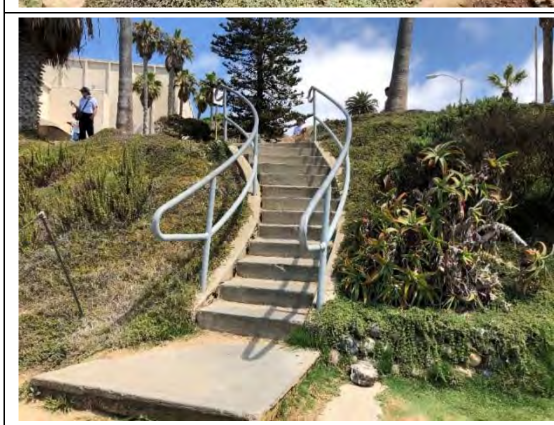
<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>53</td></tr>
<tr><td>Site Location</td><td>Park at Culver Street</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 53A from the 1993/2003 CEA document</td></tr>
<tr><td>1993

</td><td rowspan="3">2018 Observations:
The north side of the park looks as though it has experienced little to no change since 2003. The site seems to display no signs of major pedestrian hazards or enhanced erosion.

2018 Summary Update:
No apparent pedestrian hazards within the photograph
Area deemed as low risk in 2003</td></tr>
<tr><td>2003


</td></tr>
<tr><td>2018


</td></tr>
</table>

Supplemental Site 53 Photographs from 2018	
	A photograph of the path by the rock wall. The path has “warning unstable cliffs” signs, but pedestrians access the beaches through this passage regardless of the signage.
	The erosion appears to encroach the rock wall, but there is still a safe amount of space, allowing pedestrians to walk along the trail.
	A photograph of the drain by Culver Street Park.
	The staircase by Culver Street Park. There seems to be heavy vegetation within the surrounding area, and the staircase shows no obvious signs of wear.

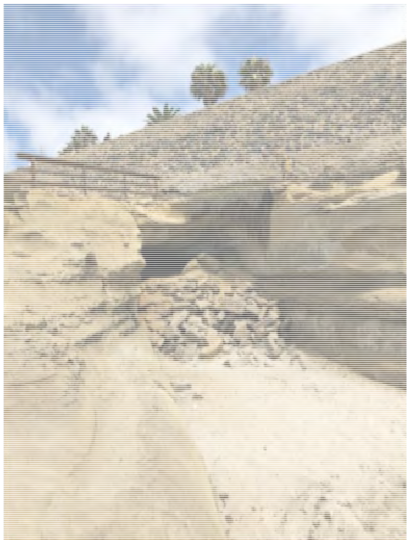
	A closer look at the Culver Street staircase.
	The coastline suggests marine and subaerial erosion.

Site 54

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>54</td></tr>
<tr><td>Site Location</td><td>Coast Boulevard Split</td></tr>
<tr><td>Priority Ratings</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 3 from Site 54C from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
There appear to be signs of marine erosion along this site. The photograph suggests that there are several sea caves forming along the bluff. The caves appear to be in the same condition as in 2003.

2018 Summary Update:
High pedestrian usage on an eroding bluff that encroaches the edge
The photograph suggests that the bluff has experienced minor marine and subaerial erosion
The photograph appears to be relatively similar to the photograph from 2003</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 54 Photographs from 2018	
	A photograph of bluff near the beaches. The erosion appears to be relatively far from the pedestrian access ways, which has made it safe for access along the path.
	The edge of the bluff seems to be several feet from the access way. Pedestrians continue to take this scenic route. The City appears to have included appropriate area restrictive signage warning about the potential consequences o walking along the trail.
	A photograph that displays Point Loma Formation, suggesting marine erosion on the face and toe of the bluff.

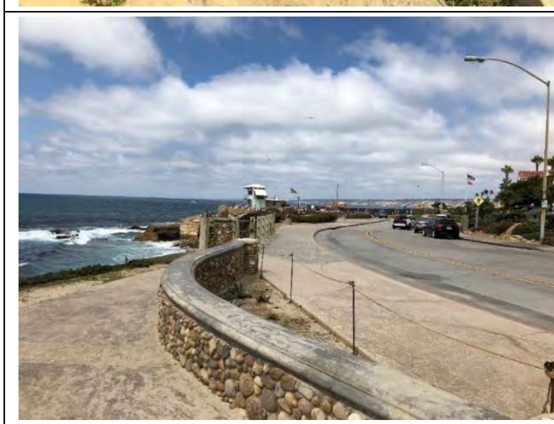
	A photograph of a collapsed cave next to the stone wall.
	A photograph of a sea cave that appears to be hollow in the middle. The cave may collapse if supplementary stress is put on the top of the cave.
	Another cave that appears to be showing fractures along its top edges.

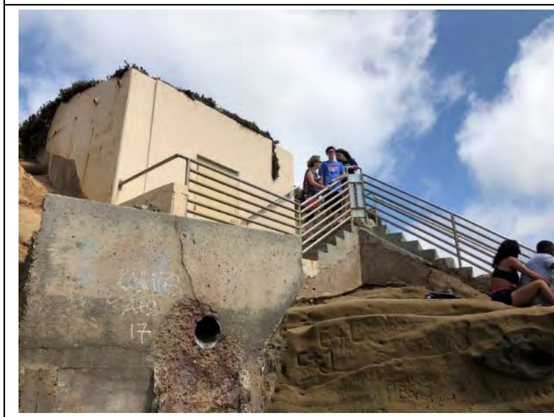
	A photograph of one of the many caves in the Site 54 region. This photograph suggests that the top of the cave has collapsed.

Site 55

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>55</td></tr>
<tr><td>Site Location</td><td>Coast Boulevard Split to Children’s Beach</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 4 from Site 55A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The photograph suggests the wooden reinforcement barrier to the right has fallen. The pathway continues to erode and approaches the edge of the road and pavement. The photograph suggests that City has smoothed out the sedimentary layering of the lower part of the bluff.

2018 Summary Update:
• The bluff trail is narrow and dangerous to pedestrian access with many uneven patches
• Wooden reinforcements and human-made bluff retreats are heavy around this area</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

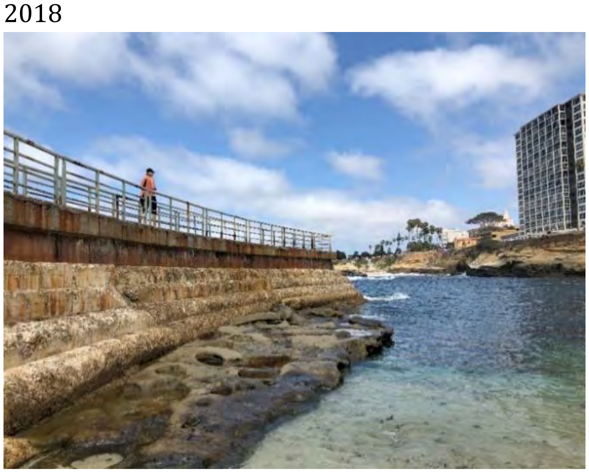
Supplemental Site 55 Photographs from 2018	
	Another view of the bluff, showing how the erosion appears to creep underneath the wooden reinforcement structure.
	A photograph highlighting the heavy vegetation within the area, with a close-up of the wooden reinforcement that supports the top of the bluff.
	A photograph of the staircase, where the surrounding area seems to be displaying signs of minor erosion.
	A photograph of the pedestrian access way road atop the heavily reinforced bluff. The area is frequently used by pedestrians and experiences a significant amount of foot traffic.

	A photograph that suggests marine and subaerial erosion along the bluff.
	A photograph of the staircase pedestrian access way next to a pump station. The area adjacent to crucial joints of the staircase displays several fractures.
	A closer look at the pump next to the staircase. The rock formations around and near the pipe appear to have eroded away. The fractures in the rocks next to the pipe suggest enhanced erosion.
	The area to the right of the staircase appears to show minor signs of marine and subaerial erosion.

	The photograph suggests enhanced erosion on the northern end of the bluff. The pedestrian access way is several feet from the edge of the bluff.

Site 56

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>56</td></tr>
<tr><td>Site Location</td><td>Coast Boulevard Split to Children’s Beach</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 56 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The seasonal high tide appears to have reduced the amount of space for pedestrians along the beach. The wall structure that surrounds Children’s Beach appears to be rustier than it was in 2003. The orange coloration of the wall suggests corrosion along the wall. The 2003 CEA report describes the wall to be in “good” condition.

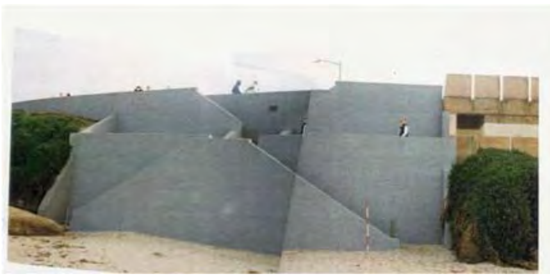
2018 Summary Update:
2003 CEA labeled the access way to be in “good” condition
No apparent pedestrian hazards within the photograph
Area deemed as low risk in 2003</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 56 Photographs from 2018	
	The wall and pedestrian railway adjacent to Children's Beach seem to display signs of corrosion.
	The lifeguard station by Children's Beach appears to be supported along a bluff that experiences marine and subaerial erosion. There appear to be cracks in the Point Loma formation layer underneath the lifeguard station.

Site 57

Site Number from 1993/2003 CEA document	57
Site Location	Coast Boulevard at Children's Beach
Priority Rating	Low
Picture number 1 from Site 57B from the 1993/2003 CEA document	

1993



2003

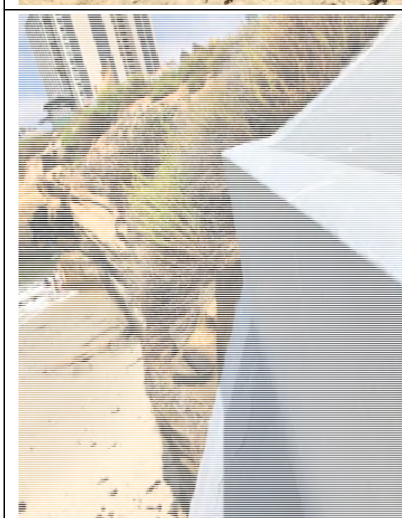
2018

2018 Observations:

The access way appears to have experienced minimal change since 2003 and appears to show no immediate signs of deterioration. The CEA report labeled the wall to be in "good" condition.

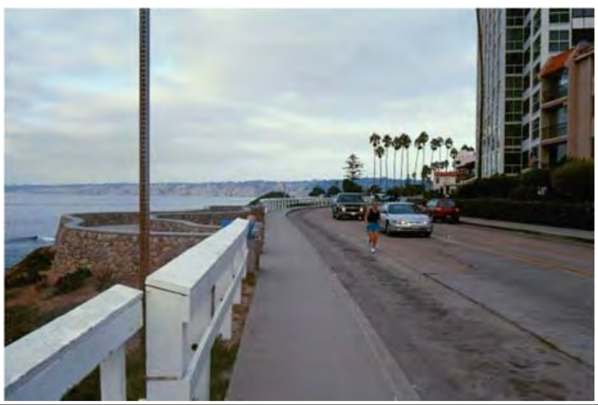
2018 Summary Update:

- 2003 CEA labeled the staircase as being in "good" condition
- No apparent pedestrian hazards within the photograph

<table>
<tr><th colspan="2">Supplemental Site 57 Photographs from 2018</th></tr>
<tr><td></td><td>The wall preventing pedestrians from accessing this path to Children's Beach helps to prevent further erosion.</td></tr>
<tr><td></td><td>A photograph of the base of the staircase shows no signs of cracks.</td></tr>
<tr><td></td><td>The photograph suggests marine and subaerial erosion north of Children's Beach. The erosion appears to approach the pedestrian access way.</td></tr>
</table>

Site 58

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>58</td></tr>
<tr><td>Site Location</td><td>Coast Boulevard-Jenner Street to Ellen Browning Scripps Park</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 1 from Site 58 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The photograph in 2018 displays little to no change since 2003. The surrounding area near the site contains many construction sites. Furthermore, the City of La Jolla appears to be improving parts of Coast Boulevard in areas not pictured in the site-representative photograph write up.

2018 Summary Update:
There appears to be marine erosion and wave erosion at the base of the cliffs</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 58 Photographs from 2018	
	A photograph of the heavily vegetated bluff area by a hotel on Coast Boulevard.
	This photograph, taken 100 feet north of the representative photograph location, suggests that the pedestrian walkway remains in similar condition to what it was in 2003. In 2003 the road was described as “safe.”

Site 59

Site Number from 1993/2003 CEA document	59
Site Location	Ellen Browning Scripps Park
Priority Rating	Low

Picture number 4 from Site 59A from the 1993/2003 CEA document

1993

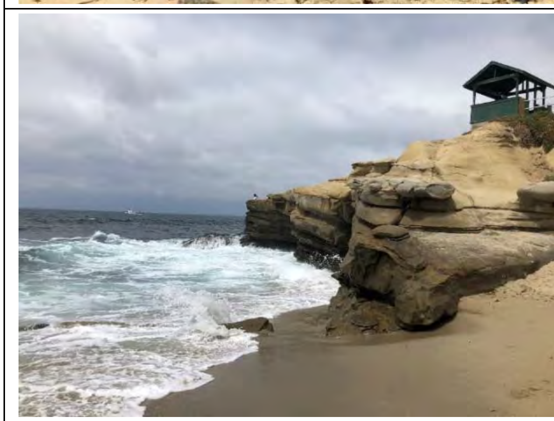
2003

2018

2018 Observations:
The channel seems to be a storm drain. However, the photograph suggests that the fence has been taken away since 2003. Pedestrians can now access this vantage point without the fence obstructing the view. There appears to be slightly less vegetation along the left side of the picture.

2018 Summary Update:

- The fence appears to have been removed since 2003
- The area appears to have experienced little to no erosion since 2003
- There does not seem to be any major signs of erosion

Supplemental Site 59 Photographs from 2018	
	A photograph of a lookout on the edge of a bluff. The edge of the bluff seems to be 3 to 4 feet from the lookout point, and the access way provides an easy downhill path for pedestrians to reach the viewpoint.
	The erosion to the area right of the staircase appears to be creeping along the slope and might be cause for concern. The bottom of the staircase where the railing ends suggests that a couple of the staircase's steps have been buried well below the sand.
	The photograph displays the 5 feet of distance between the edge of the bluff and the lookout vantage point.
	Ellen Browning Scripps Park is a popular tourist destination that experiences heavy foot traffic during the day. The park benches and pedestrian railing protection seem to show no signs of corrosion.

	The edge of the bluff suggests that there is marine and subaerial erosion. The photograph also displays the roughly 5 feet between the edge of the bluff and the lookout structure.
	A photograph displaying the Ellen Browning Park coastline highlights that the erosion appears to be encroaching the pedestrian walkway.
	The photograph suggests that there is marine erosion, which may be in issue going forward due to heavy pedestrian access atop the bluff. The bottom end of the bluff appears to be underhanging.
	A closer look at the vantage point overlooking the Pacific Ocean. The foundation support for the lookout seems to be 1 to 2 feet away from the edge of the bluff.

	A photograph of an older pedestrian protection way that appears to display signs of erosion 100 feet north of the photograph. Many pedestrians choose to access Seal Cove by jumping over the railing.
	The opposite side of the vantage point suggests that the erosion has already crept past the foundation structure.
	This photograph shows the pedestrian access way and stormwater drain, both of which display no signs of cracks and rusting. However, the erosion has encroached past the edge of the pedestrian trail wall barrier.

Site 60

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>60</td></tr>
<tr><td>Site Location</td><td>La Jolla Cove</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 6 from Site 60 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The edge of the cave looks to have further eroded at its base. The interior of the cave shows corrosion of the ceiling. The new light leak in the middle of the cave suggests a minor collapse within the cave. The additional light suggests that parts of the ceiling have collapsed.

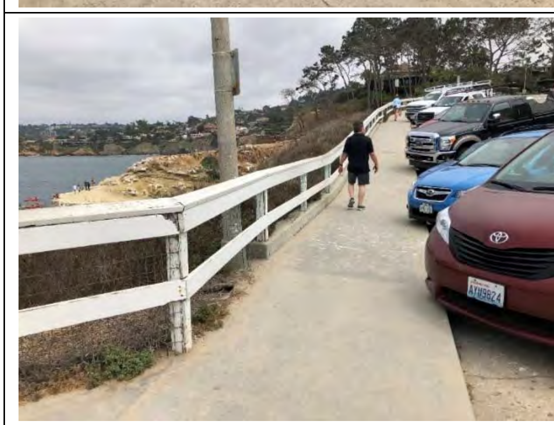
2018 Summary Update:
• The sea cave appears to show several signs of potential collapse
• Corrosion on the ceiling of the cave
• Enhanced marine and subaerial erosion</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 60 Photographs from 2018	
	A photograph of the top of La Jolla Cove. The area is an extremely popular area for tourist access.
	A photograph of the coastline, which is the home and breeding ground to many sea lions. There appears to be heavy human and sea lion interaction, and many small caves that pedestrians can explore. The caves are heavily accessed by pedestrians because it is one of San Diego's tourist-heavy locations despite signs of potential interior collapse.
	A close-up of the corrosion along the ceiling of the sea cave.

Site 61

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>61</td></tr>
<tr><td>Site Location</td><td>Coast Boulevard- La Jolla Cove</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 6 from Site 61B from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The photograph suggests that there are new slope failures. There seems to be a more pronounced area that has collapsed in the middle of the bluff. The suggested marine erosion has led to new fractures and slope failures on the face of the bluff. Many tall buildings sit atop the bluff, which is cause for concern because the bluff appears to be eroding more from the toe of the bluff rather than the face.

2018 Summary Update:
There appears to be erosion near pedestrian trails and along coastline
Many residential areas atop the bluff, and cracks forming on the road</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 61 Photographs from 2018	
	The photograph suggests that there appears to be marine erosion occurring at the toe of the bluff.
	The erosion seems to be encroaching on the pedestrian sidewalk. The signage indicates that pedestrians are not to access the points on the restricted side of the fencing.
	The additional cracks in the surface suggest minor bluff and slope movement. The City appears to be adding new infrastructure.
	The pedestrian access way railings and sidewalk on the north end of Coast Boulevard.

	A photograph of a collapsed bluff area next to the sidewalk.

Site 62

Site Number from 1993/2003 CEA document	62
Site Location	La Jolla Cove
Priority Rating	High

Picture number 6 from Site 62 from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

The height of the sea cave appears to have increased since 2003. The thickness of rock roof seems to be narrowing. There is heavy pedestrian access atop the sea cave and many kayakers and swimmers below the cliff. Pedestrians still venture past the fences that are in place to prevent people from accessing the ceiling of the sea cave.

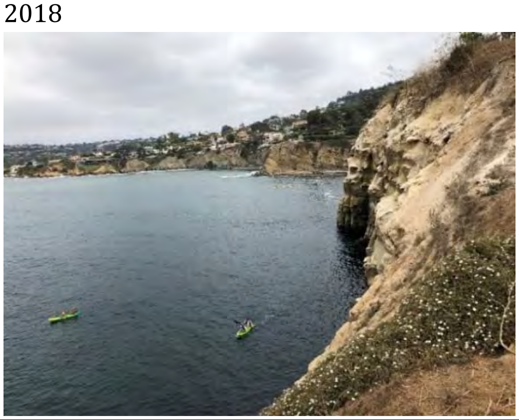
2018 Summary Update:

- Massive sea cave seems to be on the cusp of collapsing where hundreds of pedestrians' kayak and swim across
- Many pedestrians access the top of the sea cave
- The ceiling of the cave appears to be thinning

Supplemental Site 62 Photographs from 2018	
	This photograph shows a pedestrian access way used to walk alongside La Jolla residential areas.
	The fence that protects pedestrians from entering the edge of the bluff. The erosion seems to be approaching the City sidewalk.
	Signs of erosion atop the sea cave ceiling is a cause for concern and may even lead to a potential collapse of the sea cave ceiling.
	The other side of the ceiling of the sea cave. The area restrictive signage does not prevent pedestrians from accessing this part of the bluff.

Site 63

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>63</td></tr>
<tr><td>Site Location</td><td>Coast Walk</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 1 from Site 63 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">Observations:
There appear to be many sea caves within the photograph. The sea caves appear to be forming at the base of the bluff. Moreover, many of the residential areas are adding more levels to buildings and remodeling. The photograph suggests that some of the vegetation has collapsed into the ocean due to marine and subaerial erosion. There appears to be loss of vegetation on the bluff.

2018 Summary Update:
• Signs of marine and subaerial erosion
• There appears to be the formation of sea caves
• Appears to be vegetation loss on the bluff</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 63 Photographs from 2018	
	A photograph of a protection barrier pedestrian railway along the trial. The pedestrian access way is dangerously close to the edge of the bluff. The trail seems to show no major fractures excluding the area by the rail.
	A bench on the trail adjacent to residential areas that are on the bluff.
	The area surrounding the wooden reinforcement appears to be heavily eroded. The railing by the wooden reinforcement is different than the surrounding barriers, which could suggest previous bluff failure.

Site 64

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>64</td></tr>
<tr><td>Site Location</td><td>Coast Walk to 7905 Prospect Place</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 4 from Site 64A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
There appears to be a significant amount of enhanced erosion since 2003. The railing seems to be breaking at the center. The supporting land around the protection barrier railing foundations has eroded away. Moreover, the foundations seem to be on the verge of collapsing. The photograph suggests that there is erosion that is encroaching past the foundation of the railing sets. Also, the railing seems to be poorly maintained, and the City appears to have made a new access way for civilians.

2018 Summary Update:
Bluff at the end of the trail appears to have slightly collapsed
The access way seems to have been redone, but the old access way still exists</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 64 Photographs from 2018	
	The pedestrian fence does not contain any form of rust. The trail appears to be very flat and smooth.
	A photograph of the staircase on the trail. The stairs seem to be evenly spaced out and appear to not contain any cracks.
	A photograph of a staircase bridge at the end of the trail. On the opposite side of the bridge there seems to be marine erosion due to seepage.
	The City seems to have created a new pedestrian foothill access way at the end of the bridge to dissuade pedestrians from using the old access pathway.

	There seems to be new warning signs in what previously used to be a pedestrian access way at the end of the bridge.
	A photograph of the parking lot next to the stairway where there are pedestrian warning signs to discourage civilians from accessing these points.
	Pedestrians still seem to use the road instead of the footpath.

Site 65

Site Number from 1993/2003 CEA document	65
Site Location	South of La Jolla Shores
Priority Rating	Low

Picture number 1 from Site 65A from the 1993/2003 CEA document

1993

2003

2018

2018 Observations:

The private seawall appears to be in the same condition that it was before in 2003. The CEA report from 2003 reported the seawall to be in "good" condition. A large fracture seems to be forming atop the cliff. High tide prevented access to mimic the 2003 photograph. Moreover, there is no clear pedestrian access way. Pedestrians need to maneuver through slippery and mossy rocks to access the sea cave, which could lead to injuries.

2018 Summary Update:

The CEA 2003 report labeled the aging seawall to be in "good" condition

There seems to be a fracture above sea cave

Pedestrian access way seems to contain moss

Site 66

Site Number from 1993/2003 CEA document	66
Site Location	Roseland Drive to Paseo Dorado
Priority Rating	Low
Picture number 1 from Site 66 from the 1993/2003 CEA document	
1993 	**2018 Observations:** The photograph suggests that the staircase shows little to no changes since 2003. The 2003 CEA reported the area to be in "good" condition. **2018 Summary Update:** • 2003 CEA labeled the staircase as being in "good" condition • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
2003 	
2018 	

Site 67

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>67</td></tr>
<tr><td>Site Location</td><td>Avenida De La Playas to Vallecitos</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 67B from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The seawall and sidewalk appear to be relatively unchanged since 2003. The 2003 CEA report described the site to be in “good” condition.

2018 Summary Update:
2003 CEA labeled the sea wall to be in “good” condition
No apparent pedestrian hazards within the photograph
Area deemed as low risk in 2003</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 67 Photographs from 2018	
	A photograph of the entryway to La Jolla Shores. The kelp along the coastline seems to have been moved toward this end of La Jolla Shores.
	A photograph of a storm drain (on the left), and a new structure that control pedestrian and motor vehicular traffic on the beach.

Site 68

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>68</td></tr>
<tr><td>Site Location</td><td>North of La Jolla Shores Beach</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 68B from the 1993/2003 CEA document</td></tr>
<tr><td>1993

</td><td rowspan="3">2018 Observations:
The sand level seems to have risen within the last 15 years. The 48-inch-diameter storm drain shows little to no changes since 2003. The 2003 CEA report said the drain hole appears to be in “good” condition.

2018 Summary Update:
• 2003 CEA labeled the drain hole as being in “good” condition
• No apparent pedestrian hazards within the photograph
• Area deemed as low risk in 2003</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 68 Photographs from 2018	
	A photograph of the La Jolla Shores beach sea wall, which appears to have minor cracking.
	A closer look at the sidewalk of La Jolla Shores, which shows no sign of fracturing and is used heavily by pedestrians.
	A photograph of the beach at the midpoint of La Jolla Shores. The cones in the photograph designate pathways for the Lifeguard Vehicular Patrol.
	A photograph of the drain near the stair entry towards La Jolla Shores. The drains are slightly filled with sand due to the seasonal high tide.

	There does not appear to be any signs of corrosion or damage toward the restroom that are cause for concern.
	A photograph of the north end of La Jolla Shores with Scripps Pier in the distance. The entire area and lamp post seem to show no signs of erosion.

Site 69

Site Number from 1993/2003 CEA document	69
Site Location	Beach View Park (9000 La Jolla Shores Lane)
Picture number 1 from Site 69 from the 1993/2003 CEA document	
1993 	**2018 Observations:** There seems to be more vegetation around the area. Aside from the apparent increase in vegetation the area seems to be in the same condition as in 2003. **2018 Summary Update:** • No apparent pedestrian hazards within the photograph • Area deemed as low risk in 2003
2003 	
2018 	

Supplemental Site 69 Photograph from 2018	
	A photograph of the only public access trail in the site area. The potential areas of concern seem to be predominantly in residential backyards.

Site 70

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>70</td></tr>
<tr><td>Site Location</td><td>Torrey Pines Gliderport</td></tr>
<tr><td>Priority Rating</td><td>Moderate</td></tr>
<tr><td colspan="2">Picture number 6 from Site 70 from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The photograph displays the edge of the bluff along the Gliderport parking area. One of the rungs of the protection barrier structure appears to have collapsed since 2003. The erosion gully to the right of the protection barrier seems to have deepened.

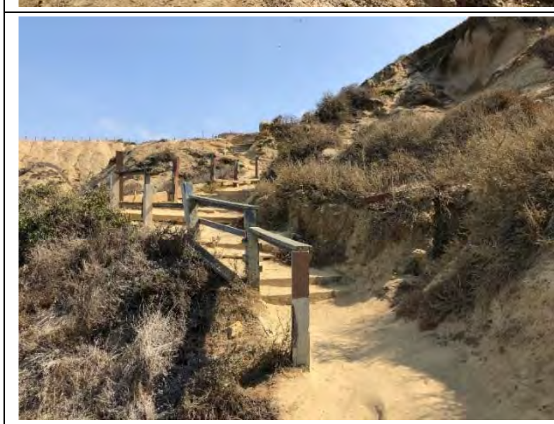
2018 Summary Update:
There appears to be marine and subaerial erosion within the site
Pedestrian barriers have come down as the edge of the bluff has eroded away</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 70 Photographs from 2018	
	A photograph of the start of the gully at the westerly edge of Gliderport displaying the channel that appears to be affected by marine and subaerial erosion.
	A photograph of the Gliderport parking lot and the vegetation adjacent to the lot.
	The edge of the erosional gully near Gliderport trail. A few of the pedestrian barriers appear to have collapsed due to erosion.

Site 71A

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>71A</td></tr>
<tr><td>Site Location</td><td>Citizen Trail to Black’s Beach from Gliderport</td></tr>
<tr><td>Priority Rating</td><td>High</td></tr>
<tr><td colspan="2">Picture number 12 from Site 71A from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
There appear to be major improvements to the staircase at the base of Black’s Beach. The trail seems to be redone to improve pedestrian access to this part of the beach. Moreover, there seems to be additional vegetation at the base of the beach. However, many areas of the path appear to be underdeveloped or human-made. Pedestrians frequently use the pathway to access Black’s Beach.

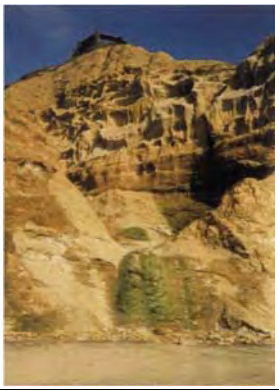
2018 Summary Update:
Many of the respective areas of the staircase have already been improved
There still appear to be unsupported human-made structures and segments that pose a risk to pedestrians accessing the path</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 71A Photographs from 2018:	
	The pedestrian foothill trail that leads toward Black's Beach. The sign contains a warning to "Stay Back," but most pedestrians go through the access way ignoring the signage.
	The first stair leading downwards to the path. The stair seems to show slight erosion along the sides. The trail appears to display slight cracks of eroded asphalt.
	A photograph of the first flight of stairs leading toward Black's Beach. Each stair seems to have slight variations in height, but the differences seem to be minor. The marine and subaerial erosion appears to be around a foot or two from parts of the staircase.
	A wooden pedestrian railway that farther along on the Black's Beach Trail. The access way is beside heavy vegetation. The path appears to be quite narrow.

	The pathway is very narrow at this point, and pedestrians who access Black's from Gliderport must step on the block shown in the photograph. The base of the small wooden block is supported by two rounded wooden structures.
	The stairs at this point appear to be slightly uneven, and differently angled. Much of the trail appears to be human-made, as indicated by the uneven nature of many of the stairs along the trail.
	The stairs at the base of Black's Beach appear to be redone and are much easier to walk down.

	The bluff adjacent to the staircase access from the Gliderport stairs. The photograph suggests marine and subaerial erosion at this point. However, the vegetation on the bluff appears to be supporting the structure.

Site 71B

<table>
<tr><td>Site Number from 1993/2003 CEA document</td><td>71B</td></tr>
<tr><td>Site Location</td><td>Black's Beach</td></tr>
<tr><td>Priority Rating</td><td>Low</td></tr>
<tr><td colspan="2">Picture number 1 from Site 71B from the 1993/2003 CEA document</td></tr>
<tr><td>1993
</td><td rowspan="3">2018 Observations:
The toe of the bluff towards the right side appears to have slightly collapsed. The photograph suggests that there is new vegetation on the bluff, which has helped to reinforce the structure. There are no immediate surroundings that are in threat, but the residential area atop the bluff might be at risk.

2018 Summary Update:
There appears to be marine and subaerial erosion within the site
Area deemed as low risk in 2003
The bluff on the right appears to have collapsed slightly</td></tr>
<tr><td>2003
</td></tr>
<tr><td>2018
</td></tr>
</table>

Supplemental Site 71B Photograph from 2018:	
	This photograph displays the bluff that runs along the coastline of Black's Beach.

Appendix D

Draft Local Coastal Program Policies

City of San Diego Draft Local Coastal Program Policies

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Draft Land Use Plan Sea Level Rise Policies: Policy Options

Incorporate the following in future LCP actions:

California Coastal Act Provisions

Section 30235 Construction altering natural shoreline

Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fish kills should be phased out or upgraded where feasible.

Section 30236 Water supply and flood control

Channelization, dams, or other substantial alterations of rivers and streams shall incorporate the best mitigation measures feasible, and be limited to (I) necessary water supply projects, (2) flood control projects where no other method for protecting existing structures in the flood plain is feasible and where such protection is necessary for public safety or to protect existing development, or (3) developments where the primary function is the improvement of fish and wildlife habitat.

Section 30253 Minimization of adverse impacts

New development shall do all of the following:

a. Minimize risks to life and property in areas of high geologic, flood, and fire hazard.
b. Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.
c. Be consistent with the requirements imposed by an air pollution control district or the State Air Resources Board as to each particular development.
d. Minimize energy consumption and vehicle miles traveled.
e. Where appropriate, protect special communities and neighborhoods that, because of their unique characteristics, are popular visitor destination points for recreational users.

Sea Level Rise Projections

Identifying and Using the Best Available Science. Use the best available, up-to-date scientific information about coastal hazards and sea level rise in vulnerability assessments, the evaluation of coastal development permit applications that present hazard risks, and the preparation of technical reports and related findings. Include multiple sea level rise scenarios in the analysis, including a worst-case "high" projection for the planning horizon or expected duration of the proposed development based on best available scientific estimates of expected sea level rise at the time of the analysis. Sources of information may include, but not be limited to, state and federal agencies, research and academic institutions, and non-governmental organizations, such as the California Coastal Commission (CCC), Ocean Protection Council (OPC), National Oceanic and Atmospheric Administration (NOAA), the National Research Council, and the Intergovernmental Panel on Climate Change. Continue to identify best available science, in keeping with regional policy efforts, as new, peer-reviewed studies on sea level rise become available and as agencies such as the OPC or the CCC issue updates to their guidance. Update vulnerability assessments and related mapping approximately every ten years, or as necessary to address significant changes in sea level rise estimates.

Sea Level Rise Policy Thresholds. Table 1 identifies the range of Sea Level Rise (SLR) projections that the City's coastal zone will be potentially subject to through Year 2100, based on the best available scientific data and in accordance with the California Coastal Commission Sea Level Rise Policy Guidance, adopted August 12, 2015 (updated November 7, 2018) and the California Coastal Commission Coastal Adaptation Planning Guidance: Residential Development, March 2018 (Revised Draft), and is used as the basis for the sea level rise policies of this document.

Table 1 *Sea Level Rise Policy Thresholds*

Sea Level Rise Scenario	**Estimated Time Range**	**Sea Level Rise Policy Threshold**
0 ft. (0 cm.)	Current	Near-term SLR ≤ X ft.
X ft. (X cm.)	2040-2080	Mid-term SLR = X to X ft.
X ft. (X cm.)	2060-2100+	Long-term SLR ≥ X ft.
X ft. (X cm.)	2080-2100+	
X ft. (X cm.)	2090-2100+	

City Planning Efforts and Programs

Sea Level Rise Data Collection and Monitoring

Monitoring data. Monitor, assess, and inform the public and City decision-makers about the effects of sea level rise on coastal resources, coastal access, public infrastructure and facilities, and existing development to make recommendations on adaptation, and revise plans and policies as needed. These include activities such as:

a. Support sea level rise modeling, vulnerability identification, and adaptation planning efforts;
b. Track NOAA tide gauge records and other resources to establish a long-term monitoring record of sea level changes;
c. Coordinate with the State Lands Commission, other state and federal agencies, other jurisdictions, academic and research institutions, and other organizations along the coast to obtain mean high tide line survey data in order to document baseline data and monitor movement of the shoreline and public trust boundary;
d. Document coastal bluff and beach erosion through photographs, mapping, and field notes;
e. Document tide conditions, storm event flooding depths and duration, wave height and frequency, beach and coastal bluff erosion, and property damage through photographs, mapping, and field notes to validate numerical modeling results and track the frequency of events; and
f. Support efforts to monitor sea level rise impacts to recreational resources (e.g., beaches), natural resources, and environmentally sensitive habitat areas.

Mid-Term and Long-Term Sea Level Rise Scenarios. When sea level rise has reached specific measured thresholds, apply mid-term and long-term sea level rise scenarios.

Sea Level Rise Potential Hazard Maps

Mapping Coastal Hazards. Map areas subject to existing and future coastal hazards, including hazards that are anticipated to be exacerbated by sea level rise, that present risks to life and/or property. Develop coastal hazard maps that show areas of the City that are anticipated to be subject to current or future coastal hazards, using multiple sea level rise scenarios to identify appropriate design standards and evaluate long term planning opportunities. Consider the range of sea level rise projections based on best available science. Coastal hazard areas include, but are not limited to the following:

- Coastal bluff erosion areas
- Beach erosion hazards areas
- Storm flood extent areas (estuarine or riverine related)
- Wave run up (Areas subject to direct wave attack and damage from wave runup)
- Tidal inundation (Areas where routine inundation from tides occurs now and where inundation is likely to occur in the future with sea level rise)
- Groundwater Inundation (Current and future areas subject to hazards caused by elevated groundwater and/or reduced or inadequate drainage)

a. Evaluate development proposed in potential hazard areas, including those mapped as hazardous *[insert reference to Coastal Hazard maps referenced above, e.g. in Figure X],* for potential coastal hazards at the site, based on all readily available information and the best available science. Ensure that such development, subject to coastal hazards, can be built consistent with Development Review Policies for coastal development.
b. Update Coastal Hazard maps as new science and modeling results and/or state guidance become available, approximately every 10 years or more frequently as necessary.

Potential Hazards and Maps. The City of San Diego's coastal zone contains areas subject to existing and future natural hazards that may present risks to life and/or property. Activity on all discrete parcels located wholly or partially within the long-term sea level rise scenarios (*X ft. of sea level rise*), defined in *Maps X (pages x*) as listed below, require additional development considerations to minimize risks set forth in the "Development Review Policies" herein, including site-specific coastal hazards report requirements.

a. *Map X* depicts hazard screening areas potentially subject to shoreline hazards including: beach erosion; coastal bluff erosion; coastal bluff slope failure or instability; coastal flooding; and wave impacts, now and in the future, factoring in the effects of sea level rise. *Map X* is based on data from geological investigations, surveys, aerial photos, best available science modeling of sea level rise, and other sources. The map depicts areas potentially impacted from shoreline hazards resulting from *X* cm of sea level rise with a 100-year storm event. *Map X* provides a screening-level tool that depicts where site specific technical evaluations may be required and where development standards pertaining to shoreline hazard areas may be applied as set forth in the Development Review Policies.
   i. There are X Potential Shoreline Hazards Screening areas, as follows: [*insert maps based on LCP Planning Area*]

Hazard Preparedness

Emergency Planning. Revise the City's Hazard Mitigation Plan (HMP) to incorporate relevant findings from the *City of San Diego Climate Change Vulnerability Assessment,* and support emergency planning to minimize disruption to City services (such as water, wastewater, power, and roads) due to temporary flooding or power outages associated with tide gate malfunction or sea level rise.

Repetitive Loss. For structures that suffer damages and file FEMA claims on two of more occasions in a 10-year time period, consider rezoning the property a less intensive uses, or to limit reconstruction and to accommodate increased coastal flooding inundation, and related sea level rise impacts, or consider City acquisition of the property.

Upgrade Existing City Infrastructure. Prioritize upgrades to improve the resiliency of City assets to temporary flooding events through retrofits, increased redundancy of key systems, or relocation. Focus primary efforts on reducing current exposure to at-risk assets such as: *[insert assets based on developed risk profiles]*.

Sea Level Rise Adaptation Plan. Develop and implement a climate change adaptation plan (*Climate Resilient SD)* that addresses the feasibility, economic impacts, costs, and benefits of a range of adaptation strategies. Include recommendations for adapting existing development, public improvements, coastal access, recreational areas, and other coastal resources. When applicable, prioritize “soft” adaptation strategies such as beach nourishment, living shorelines, and dune restoration over “hard” adaptation strategies such as seawalls or groins. Coordinate with other regional jurisdictions and entities working on sea level rise issues and consider the California Natural Resources Agency’s Safeguarding California Plans for Reducing Climate Risk and the California Coastal Commission’s Sea Level Rise Policy Guidance. Update the adaptation plan as new science and/or state guidance becomes available.

Development Review Policies

Development and Permit Standards in Potential Coastal Hazard Areas

Siting to Protect Coastal Resources and Minimize Hazards. Site new development in a manner that minimizes exposure to hazards, including projected sea level rise and potential impacts to groundwater, over the anticipated life of the development. If hazards cannot be avoided, site and design development to protect coastal resources and minimize risks to life and property to the extent feasible. Address stability and structural integrity of development without reliance on shoreline protective devices that substantially alter natural landforms along bluffs and cliffs or otherwise harm coastal resources in a manner inconsistent with LCP policies or Coastal Act public access policies, and that does not contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area.

Adaptation in Development. Consider the expected life of proposed development and the best available information on climate change effects, particularly sea level rise, and incorporate adaptation measures, as needed, in the location, siting, and design of coastal structures.

Anticipated Lifespan of Development. The appropriate time horizon for the evaluation of sea level rise depends on the anticipated duration of development, after which such development is expected to be removed, replaced or redeveloped. For example, if a new structure has an anticipated duration of 75 years, then evaluate the site over 75 years, evaluating the range of projected sea level rise over that time period. Using that evaluation, design to avoid hazards over the planning horizon, if feasible. If avoidance is infeasible, design to minimize flooding and geologic risk and assure structural stability over the planning horizon. Use anticipated life of development in the coastal zone for sea level rise planning purposes, and is generally defined by the following general timeframes, unless a site or project specific analysis determines otherwise:

a. Ancillary development or amenity structures (e.g. trails, bike racks, playgrounds, parking lots, shoreline restrooms): 5-25 years
b. Manufactured or mobile homes: 30-55 years
c. Residential or commercial structures: 75-100 years
d. Critical infrastructure:
    i. Asphalt roadways: 25-50 years
    ii. Concrete pavement: 50-75 years
    iii. Bridges: 75 years
    iv. Water mains: 100 years
    v. Storm drains: 100 years
    vi. Electrical and gas: 100 years

Coastal Development Permit (CDP) Site-specific Coastal Hazard Reports. For projects within the hazard areas (*Maps X*), CDP applicants for all development, except for temporary structures, to submit a site-specific coastal hazard report prepared by a licensed civil engineer with expertise in coastal engineering and geomorphology or other suitably qualified professional. Require the report on the best available science, consider the impacts for the range of sea level rise projections for the anticipated duration of the proposed development, demonstrate that the development will avoid or minimize impacts from coastal hazards, and evaluate the foreseeable effects that the development will have on coastal resources over time (including in terms of impacts on public access, shoreline dynamics, natural landforms, natural shoreline processes, and public views) as project impacts continue and/or change over time, including in response to sea level rise.

Coastal Development Permit (CDP) Site-specific Coastal Hazard Report Contents. Include in the Coastal Hazard Report analysis of the physical impacts from coastal hazards and sea level rise that might constrain the project site and/or impact the proposed development. Address and demonstrate the site hazards and effects of the proposed development on coastal resources, including discussion, maps, profiles and/or other relevant information that describe the following:

a. Current conditions at the site, including the current tidal range, referenced to an identified vertical datum, including the current mean high tide line; intertidal zone; inland extent of flooding associated with extreme tidal conditions and storm events; beach erosion rates (both long-term and seasonal variability), and bluff erosion rates (both long-term and episodic)
b. Projected future conditions at the site, accounting for sea level rise over the anticipated duration of the development, including shoreline, dune, or bluff edge, accounting for long-term erosion and assuming an increase in erosion from sea level rise; intertidal zone, and inland extent of flooding and wave run-up associated with both storm and non-storm conditions
c. Safety of the proposed structure to withstand current and projected future hazards for its anticipated duration, including: identification of a safe building envelope on the site that avoids hazards; identification of options to minimize hazards if no safe building envelope exists that would allow avoidance of hazards; analysis of the adequacy of the proposed building/foundation design to ensure stability of the development relative to expected wave run-up, flooding and groundwater inundation (e.g., hydrostatic loads, uplift, or possible corrosion) for the anticipated duration of the development in both storm and non-storm conditions, and description of any proposed future sea level rise adaptation measures.
d. Discussion of the study and assumptions used in the analysis including a description of the calculations used to determine long-term erosion impacts and the elevation and inland extent of current and future flooding and wave runup.
e. For blufftop development, a detailed analysis of erosion risks, including the following:
    - Evaluate the predicted bluff edge, shoreline position, or dune profile considering not only historical retreat, but also acceleration of retreat due to continued and accelerated sea level rise and other climatic impacts. Determine future long-term erosion rates should be based upon the best available information, using resources such as the highest historic retreat rates, sea level rise model flood projections, or shoreline/bluff/dune change models that take rising sea levels into account. Include a quantitative slope stability analysis demonstrating a minimum factor of safety against sliding of 1.5 (static) and 1.1 (pseudostatic, k=0.15 or determined through a quantitative slope stability analysis by a geotechnical engineer), for bluff development proposals where safety and stability is be demonstrated for the predicted position of the bluff and bluff edge following bluff recession over the identified project life, without the need for caissons or other protective devices. The analysis should consider impacts both with and without any existing shoreline protective devices.

f. For development on a beach, dune, low bluff, or other shoreline property subject to coastal flooding, inundation, or erosion, include a wave runup and impact report and analysis, including the following:
    - Consideration of current flood hazards as well as flood hazards associated with sea level rise over the anticipated duration of the development. To examine risks and impacts from flooding, including daily tidal inundation, wave impacts, runup, and overtopping, the site should be examined under conditions of a beach subject to long-term erosion and seasonally eroded shoreline combined with a large storm event (1% probability of occurrence). Flood risks should take into account daily and annual high tide conditions, backwater flooding, water level rise due to El Niño and other atmospheric forcing, groundwater inundation, storm surge, sea level rise appropriate for the time period, and waves associated with a large storm event (such as the 100-year storm or greater).
    - Examine a range of sea level rise scenarios to understand the range of potential impacts that may occur throughout the anticipated duration of the development. At a minimum, flood risk for the range of sea level rise projections over the anticipated duration of the development, based on the current best available science, should be examined. Additionally, the analysis should consider the frequency of future flooding impacts (e.g., daily impacts versus flooding from extreme storms only) and describe the extent to which the proposed development would avoid, minimize, and/or withstand impacts from such occurrences of flooding. Studies should describe adaptation strategies that reduce hazard risks and neither create nor add to impacts on existing coastal resources.

Conditions of Approval for CDPs. For development in hazardous areas, including as identified in *Maps X* or as demonstrated by a site-specific coastal hazard report, discourage new development unless such development has been sited and designed to avoid, or reduce to the extent feasible, hazards and coastal resources impacts and to take into account adaptive management strategies for sea level rise. Ensure stability and structural integrity for the anticipated lifespan of the development. For any areas located within the hazard areas identified on *Maps X* or in hazardous areas as demonstrated by a site-specific hazard study, include the following conditions of approval:

a. Implementation of mitigation measures for any unavoidable coastal resource impacts as identified in the site-specific hazard study, including any necessary monitoring requirements.
b. Indemnify the City from liability for any personal or property damage caused by geologic or other hazards on such properties and record a deed restriction that identifies the risks to the property associated with sea level rise, including: risks demonstrated in a site specific analysis; unless a protective device is allowed per *Policy X (Shoreline Protective Devices*), a waiver of any rights that may exist under applicable law to construct a shoreline protective device(s) at any point in the future to protect the development approved pursuant to the applicable CDP; and that public funds are not available or allowed to be allocated to remedy damage to public roadways, infrastructure, and other facilities resulting from natural events such as sea level rise.
c. For new development, where relocation and/or structure removal may be necessary at some time in the future, consider foundation designs or other aspects of the development will accommodate future relocation and/or structure removal. Such

relocation and/or removal shall be demonstrated in final plans, and may be phased over time. Alternative design options should be considered and employed where appropriate and if site conditions allow, such as constructing smaller structures, increasing finished floor elevations, and installing wall flood vents.

d. Consider requiring removal of the authorized development and restoration of the area to its natural condition if any of the following occur:
    i. The City has ordered that the development is not to be occupied due to imminent threat to occupants' health and safety; and/or
    ii. The City has determined that services to the site can no longer be maintained (e.g., utilities, roads); and/or
    iii. The development is no longer located on private property due to the migration of the public trust boundary.

Flood Hazard Zone Development. Construct development in hazardous flood areas as depicted on *Maps X*, or on the effective Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) to not obstruct to flood control or adversely affect migrating tidelands, coastal wetlands, estuaries, or other sensitive habitat areas within the floodplain and adhere to the following specific building and siting criteria:

a. Within flood hazard areas as mapped by FEMA, construct development to meets minimum elevation requirements of the Base Flood Elevation (BFE) assigned to a specific flood zone on a FIRM or the projected sea level rise amount expected for the anticipated lifespan of the development, whichever is greater.
b. Within areas that are not within FEMA mapped flood zones but are identified as within *Maps X,* construct development such that the lowest finished floor exceeds the highest natural elevation of the ground surface next to the proposed walls of the structure prior to construction (i.e. highest adjacent grade) by an amount equal or greater than the projected sea level rise expected for the anticipated lifespan of the structure.

Substantial Redevelopment. A development proposal reaches the threshold of being a replacement structure or substantial redevelopment if it meets the criteria below. Ensure development that meets this definition is brought into conformance with all coastal resource protection policies in the LCP.

Development that consists of alterations including (1) additions to an existing structure, (2) exterior renovations, and/or (3) demolition or replacement of an existing home or other principal structure, or portions thereof, which results in either:

a. Replacement (including demolition, renovation or alteration) of 50% or more of major structural components including exterior walls, floor, roof structure or foundation, or a 50% increase in gross floor area. Alterations are not additive between individual major structural components; or
b. Replacement (including demolition, renovation or alteration) of less than 50% of a major structural component where the proposed replacement would result in cumulative alterations exceeding 50% or more of that major structural component, taking into consideration previous replacement work undertaken on or after January 1, 1977; or an alteration that constitutes less than 50%

increase in floor area where the proposed alteration would result in a cumulative addition of 50% or greater of the floor area, taking into consideration previous additions undertaken on or after January 1, 1977.

Non-Conforming Structures in Hazardous Locations. When proposed development would involve redevelopment of an existing structure that is legally non-conforming due to a coastal resource protection standard, ensure that it conforms with all current coastal resource protection standards and policies of the LCP and, if applicable, the Coastal Act. Discourage non-exempt improvements to existing non-conforming structures, regardless if the proposed improvements meet the threshold of redevelopment, when the improvements increase the degree of non-conformity of the existing structure by, for example, increasing the hazardous condition, developing seaward, or increasing the size of the structure in a non-conforming location.

Reduction of Greenhouse Gases (GHGs). Encourage all new development and redevelopment to incorporate weatherizing techniques, solar panels, and other such techniques to reduce GHGs to the extent feasible, where compatible with community character, coastal views, and protection of biological resources.

Green Infrastructure. Encourage new development and redevelopment to prioritize methods that utilize natural drainage systems such as bioswales, permeable pavements, and green roofs.

Soft Shoreline Protection. Encourage the use of soft or natural shoreline protection methods, such as dune restoration, beach/sand nourishment, living shorelines, horizontal levees, and other “green” infrastructure as alternatives to hard shoreline protective devices, where applicable. Evaluate soft shoreline protection devices for coastal resource impacts. Consider how these options may need to change over time as sea level rises.

California State Lands Commission Jurisdiction. Disallow proposed development on a beach or along the shoreline, including a shoreline protection structure, located within the jurisdiction of the California State Lands Commission.

a. If the California State Lands Commission determines that the proposed development is located on public tidelands or would adversely impact public tidelands, unless the State Lands Commission, after fully considering its obligation to protect public trust lands, authorizes the development on, and use of, trust lands in writing.

Shoreline Protective Devices

Shoreline Protective Device Permitting.

a. Discourage new or substantially redeveloped shoreline protection devices unless avoidance measures, including consideration of relocation or removal of the at-risk structure, beach nourishment, dune creation, dune restoration, and other similar techniques are technically infeasible. Encourage shoreline protection devices to accomplish the intent of protecting public beaches, coastal dependent uses, existing public structures, and existing principal structures (main living quarters, main commercial buildings, and functionally necessary appurtenances to those structures, such as wastewater and water systems, utilities, and other infrastructure) in danger from erosion. Shoreline protection devices shall not be allowed for the sole purpose of protecting private accessory structures or landscape features (e.g., garages, carports, storage sheds, decks, patios, walkways, landscaping).

b. For shoreline protection devices:
   i. Site as far landward as feasible;
   ii. Design to factor in the effects of sea level rise, including associated changes to beach erosion, coastal bluff erosion, coastal flooding, and wave impacts over the expected life of the development;
   iii. Design to have the smallest footprint feasible;
   iv. Minimize alterations of the natural landform and natural shoreline processes to the extent feasible;
   v. Limit encroachment upon beach area that impedes lateral public access along the beach at any tide condition. If technically infeasible to avoid impeding lateral access along the beach at any tide condition, mitigate to provide equivalent lateral access to that portion of shoreline in an alternate location;
   vi. Strive to maintain public access to and along the shoreline and coastal recreation areas to the maximum extent feasible through project siting and design and required mitigation; and
   vii. Preserve local shoreline sand supply.

Conditions of Approval for Shoreline Protective Devices for Private Development., Include the following conditions in Coastal Development Permits for new or substantially redeveloped shoreline protection devices:

a. Remove shoreline protection device when the structure, or use requiring protection, is removed and the shoreline protection device is no longer needed for its permitted purpose; or the existing structure it is protecting is substantially redeveloped, removed, or no longer exists.
b. Address impacts to public access and sand supply pursuant to *Policy X Shoreline Protection Device Permitting;*
c. Limit the Coastal Development Permit to a maximum twenty (20) year term;
d. Periodically monitor and reassess impacts. Mitigate as necessary to address any adverse impacts at the end of the permit term or when improvements are proposed that extend the life of the device, whichever comes first; and

Conditions of Approval for Shoreline Protective Devices for Public Development. Coastal Development Permits for new or substantially redeveloped shoreline protection devices for public development include:

a. Remove shoreline protection devices when the structure or, use requiring protection, is removed and the shoreline protection device is no longer needed for its permitted purpose; or the existing structure, public beach, coastal recreation area, or coastal dependent uses it is protecting are removed or no longer exist.
b. Address impacts to public access and sand supply pursuant to *Policy X Shoreline Protection Device Permitting*;
c. Periodically monitor and reassess impacts at end of the permit term or when improvements are proposed that extend the life of the device, whichever comes first; and

d. Reevaluate the design and necessity of the shoreline protection device when the protected structure is substantially redeveloped.

Repair and Maintenance of Shoreline Protective Devices. Allow on-exempt repair and maintenance of existing, legally permitted shoreline protective devices as repair and maintenance if the activities do not result in an enlargement or extension of armoring and do not result in a seaward encroachment of the shoreline protective device or substantially impair public trust resources. Include measures to address and mitigate coastal resource impacts that repair and maintenance activities may cause, including impacts to local sand supply, public views, and public recreational access.

Bluff Development

Bluff Face Development. Prohibit structures, grading, and landform alteration on bluff faces, except for public access structures where no feasible alternative means of public access exists, and shoreline protective devices is otherwise consistent with the LCP and the Coastal Act public access and recreation policies. Ensure structures are designed and constructed to be visually compatible with the surrounding area to the extent feasible and to minimize effects on bluff face erosion.

Determining Bluff Setback Line. In determining the bluff or geologic setback line (the location on the bluff top inland of which stability can be reasonably assured for the anticipated duration of the development without need for shoreline protective devices), account for the amount of erosion anticipated over the life of the development, plus an additional setback to ensure structural stability under future conditions. Consider requiring applications for bluff property development to include a geotechnical report from a licensed Geotechnical Engineer or a certified Engineering Geologist that establishes the bluff or geologic setback line for the proposed development, that includes a quantitative slope stability analysis that demonstrates a minimum factor of safety against sliding of 1.5 (static) or 1.1 (pseudostatic, k-0.15 or determined through analysis by the geotechnical engineer), using shear strength parameters derived from relatively undeformed samples collected at the site. Base future long term erosion rates upon the best available information on bluff failure mechanisms, using resources such as the historic retreat rates, sea level rise flood projections, shoreline change models that consider sea level rise, future increase in storm, El Niño or other climatic events, and any known site-specific conditions. Account for the future potential of any current shoreline protective device being removed.

Minor Development along Bluffs. Allow minor and/or ancillary development, including *[insert relevant development types based on existing pattern of development and consistent with view protection policies, e.g., public trails, benches, gazebos, patios]*, to be located seaward of the bluff or shoreline setback line, but no closer than *[insert appropriate distance]* inland of the bluff edge, provided that development does not use a foundation that can serve as a bluff retaining device, such as caissons, or that requires landform alteration, and that the development is removed or relocated when threatened. In the event that portions of the development fall to the bluffs, beach, or ocean before are removal or relocation, ensure removal of all recoverable debris associated with the development from the bluffs, beach and ocean through CDP conditions (unless no CDP is required) and lawfully dispose of the material in an approved disposal site.

Waterfront Development

Bulkhead Permitting. Allow new development or redevelopment on property currently protected from flooding by bulkheads to rely on those bulkheads to demonstrate that the project would protect life and property from coastal hazards if: 1) the existing bulkheads, and feasible augmentation to protect the proposed structure over its life, do not alter natural shoreline processes along bluffs or cliffs or cause adverse impacts to public access, marine habitat, aesthetics, or other coastal resources protected in the LCP, including when considering migration of public trust lands and impacts from anticipated groundwater changes; Discourage future shoreline protection including repair or maintenance, enhancement, reinforcement, or any other activity affecting the bulkhead, that results in any encroachment seaward of the authorized footprint of the bulkhead. The principal structure(s) should be set back a sufficient distance to allow for repair and maintenance of that bulkhead including access to any subsurface deadman or tiebacks and to allow for realignment of necessary bulkheads as far landward as possible and in alignment with bulkheads on either side.

Public Access, Recreation, and Public Facilities

Shoreline Public Access Facilities. Allow shoreline public access facilities and improvements to existing facilities, including public walkways and bike trails, public restrooms, public stairways and/or public ramps, within the hazardous areas identified on Coastal Hazard Maps, a project:

a. Is consistent with all other applicable LCP policies,
b. Is sited and designed to be easily relocatable and/or removable without significant damage to shoreline areas and conditioned to require such relocation/removal prior to the development becoming structurally unstable, or otherwise unsafe for its intended use, and
c. Is not anticipated to cause, expand, or accelerate instability of shoreline erosion.

Habitat Buffers for Sea Level Rise

Establish a buffer of at least *[insert distance of buffer]* feet in width from the edge of wetlands or other environmentally sensitive habitat areas and at least *[insert distance of buffer]* feet in width from the edge of riparian habitat that includes an additional sea level rise buffer area to the habitat buffer, as necessary, to allow for the migration of wetlands and other shoreline habitats caused by sea level rise over the anticipated duration of the development. Limit uses and development within sea level rise buffer areas to minor passive recreational uses, with fencing, desiltation or erosion control facilities, or other improvements needed to protect the habitat and to be located in the upper (upland) half of the buffer area. Discourage water quality features, such as drainage swales, required to support new development, in wetland buffers. However, allow temporary uses in the sea level rise buffer area until such time as sea level rise causes the wetlands or other shoreline habitat to migrate to within 100 feet of the temporary uses. Permanently conserve or protect habitat and buffers Site and design development, including grading, that is adjacent to, or that would drain directly to an environmentally sensitive habitat area in a manner that would not significantly degrade habitat values, impair functional capacity, or impair the continuance of the habitat area.

Adaptive Management Programs

Beach Management Plan. Consider development of a comprehensive beach management plan to protect and enhance existing beach areas. Within the plan, identify potential near term, as well as longer term actions and programs that would preserve recreational, habitat, and other coastal resource values. Identify opportunities for additional adaptation actions that would be implemented based on future impacts. Consider including:

a. Establishment of a minimum beach width for public recreational access and habitat function, considering daily tidal range, seasonal erosion, and short-term, storm driven erosion.
b. Coordination with sediment management plan actions and establishment of appropriate triggers for sediment management activities so that the appropriate width is maintained as the beach naturally migrates over time in response to erosion, sea level rise, and other coastal processes.
c. Monitoring beach width, mean high tide line, and bluff toe elevation.
d. Monitoring public access, beach use, and any impacts to public trust lands and identification and tracking of locations, times, and durations throughout the year when the beach is too narrow for adequate recreation and/or lateral access.
e. Pursuing opportunities for beach nourishment or otherwise increasing beach widths and enhancing beach access.
f. Evaluating adaptation opportunities for vulnerable roads and highways that provide beach access, and pursuing opportunities that would maintain vehicular, bicycle, and pedestrian access while protecting the beach and public access.

Beach Nourishment.

a. Allow the placement of sediments at appropriate points along the shoreline that were removed from erosion control or flood control facilities for the purpose of beach nourishment if the source material proposed for deposition contains the physical (e.g., grain size and type), chemical, color, particle shape, debris, and compatibility characteristics appropriate for beach replenishment.
b. Design beach nourishment projects to: minimize adverse impacts to beach, intertidal, and offshore resources; incorporate appropriate mitigation measures; and consider the method, location, and timing of placement.
c. Allow sediment removed from catchment basins to be disposed of in the littoral system if it is tested and is found to have suitable physical, chemical, color, particle shape, debris, and compatibility characteristics appropriate for beach replenishment.

Mid-Term Sea Level Rise

When mid-term sea level rise projection levels are realized, based on monitoring, (*sea level greater than X ft.; see Table X)* additional policies may include:

Development. Limit new development on properties that have experienced damage to more than *X%* of the existing structures/developments or have been partially or wholly exposed to continuous storm flooding for a tide cycle (6 hours) more than *X times a year for a X-year period,* to small, easily-movable structures (excluding shoreline protective devices) built at low densities. Require such structures to be removed if the City determines that they are interfering with coastal resources or critical public infrastructure, or if they are no longer located on private property due to the movement of the public trust boundary.

Development Impact Fee Program. For properties located within a hazard area, as identified on *Maps X,* consider establishing a Development Impact Fee Program to be used to fund activities and programs that address conditions arising from sea level rise along the San Diego coast, as allowed under the California Mitigation Fee Act.

Long-Term Sea Level Rise

When sea level rise prediction levels are realized, (*sea level greater than X ft.; see Table* X). based on monitoring, additional policies may include:

New Public Infrastructure in Hazard Areas. In hazard areas that have experienced damage to more than *X%* of the existing structures/developments or have been partially or wholly exposed to continuous storm flooding for a tide cycle (6 hours) *more than X times a year for a X-year period*, prohibit new public infrastructure (e.g. roads, pipes, storm drains, pump stations, equipment boxes) except as necessary to support continued economic viability of water-dependent uses and/or public coastal access.

Additional Coastal Hazards

Seismic and Liquefaction Area Hazard Standards. Ensure that development in areas as depicted on *Map X*, Seismic/Liquefaction Coastal Hazard Zone, meets the seismic safety standards of the Alquist-Priolo Act (Calif. Public Resources Code Section 2621, et seq.).

Tsunami Hazards. Review and periodically update local and distant tsunami inundation maps for the City to identify susceptible areas and plan evacuation routes.

Tsunami Hazards. Support and participate in local and regional efforts to develop, implement, and update tsunami response plans and evacuation routes, including enhancing the tsunami warning capability as technologies evolve, conducting public education and readiness measures with special attention on vulnerable neighborhoods, posting Tsunami Hazard Zone signs, and developing response-planning programs.

Environmental Justice

Environmental Justice. Promote engagement within communities of concern in public decision-making regarding coastal hazards and prioritize infrastructure improvements that address access to public recreation and beach areas.

Environmental Justice. In collaboration with public, private, and nonprofit partners, work to increase the resilience to climate change related risks (increasing temperatures and heat related effects, wildfires, reduced water supply, poor air quality, and sea level rise), and target adaptation implementation in the most vulnerable communities.

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